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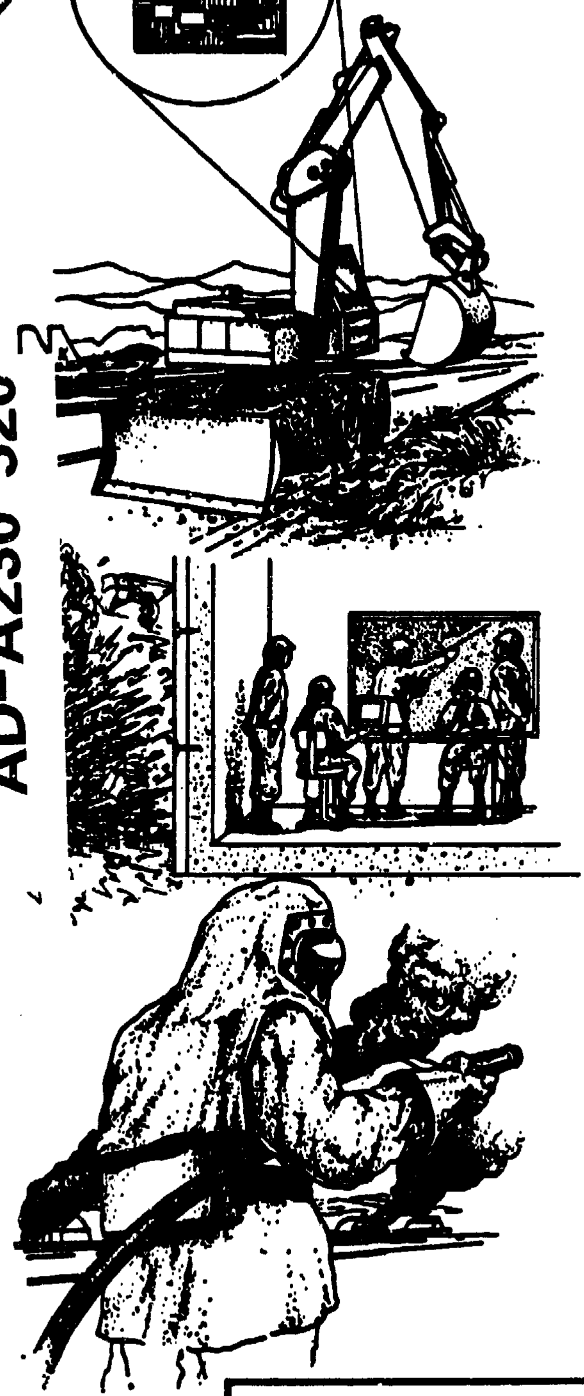

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# THERMODYNAMIC PROPERTIES OF REFRIGERANT MIXTURES

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JANUARY 1990

FINAL REPORT

JUNE 1989 — DEC 1989

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**13. ABSTRACT** *(Maximum 200 words)*

The objective of this project was to analyze the impact of refrigerant mixtures on refrigeration system capacity and components. A heat pump computer simulator was developed to predict the change in system capacity of two baseline air-conditioning systems as a function of refrigerant mixture concentration. Refrigerant mixtures made of refrigerants normally stocked on Air Force bases were considered.

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# EXECUTIVE SUMMARY


The objective of this Phase I SBIR research effort, conducted between 21 June 1989 and 21 December 1989, was to analyze the impact of various refrigerant mixtures on refrigeration system capacity and components. This information would be essential if an attack on an Air Force base results in loss of refrigerant in the air-conditioning system and in base stockpiles, forcing replacement with a refrigerant alternative.

Technical literature was searched to find the necessary data on refrigerants normally stocked at Air Force bases. This data was obtained for refrigerants R-11, R-12, R-13B1, R-22, R-502, and R-290. A heat pump computer simulator was then developed to model the various refrigerant mixtures in two baseline refrigeration systems, a 50-kW R-22 system and a 430-kW R-11 system. The simulator used an equation of state to predict the thermodynamic properties of the refrigerant mixtures. Mainstream modeled the expansion device two ways; with a thermostatic expansion valve (TXV), like the baseline system, and with a generic expansion device, which is an idealized model. The TXV approach was the most indicative of actual system performance since this is the type of device used in the baseline systems. Using the TXV approach, adverse affects on system components (such as liquid slugging in the compressor and water chiller freezing) could be predicted. These affects could not be predicted using the generic expansion device.

The modeling results for the 50-kW R-22 system showed that the R-22/R-502 is the most desirable mixture candidate for that system, resulting in a slight decrease in system capacity. The mixture R-22/R-13B1 also resulted in a decrease in system capacity, but the potential for freezing in the system water chiller exists above 20 wt% R-13B1. The mixture R-22/R-12 also resulted in a decrease in system capacity, but liquid slugging in the compressor (resulting in compressor failure) is a problem above 60 wt% R-12. The mixture R-22/R-290 is not suitable because the power requirement in the compressor increased over the baseline system, causing compressor failure. The mixture R-22/R-11 is not suitable because liquid slugging in the compressor will occur, causing compressor failure. The modeling results for the 430-kW R-11 system showed that the mixture R-11/R-12 is not a desirable candidate for that system. The compressor power requirement for this mixture increased significantly over the baseline system, causing compressor failure. The mixture R-11/R-22 is also not desirable because of the increase in the compressor power requirement.

Further research should validate the Phase I performance results using a heat pump test stand apparatus. This would allow for studying the effects of mixtures on system hardware, as well. Additional work should also identify suitable mixtures for the R-11 system and investigate system hardware improvements to fully utilize the advantages of refrigerant mixtures.




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## PREFACE

This report was prepared by the Thermal Systems Division of Mainctream Engineering Corporation, 200 Yellow Place, Rockledge, FL 32955, under contract F08635-89-C-0354, for the Air Force Engineering and Services Center, Engineering and Services Laboratory, Tyndall Air Force Base, Florida. Captain Isaac J. Schantz was the Government technical program manager.

This report summarizes work done between 21 June 1989 and 21 December 1989.

Mainstream Engineering Corporation gratefully acknowledges Dr. Mark O. McLinden of the National Institute of Standards and Technology, Boulder, Colorado, for supplying the Fortran source code for the CSD equation of state and accompanying property routines.

This report has been reviewed by the Public Affairs Office and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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# TABLE OF CONTENTS

# TABLE OF CONTENTS (CONCLUDED)

# LIST OF FIGURES

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# SECTION I

# INTRODUCTION

## A. OBJECTIVE

This final report addresses topic AF89-064, Thermodynamics of Advanced Refrigerants, from 1989 SBIR Solicitation 89.1. The objective was to analyze the impact of various refrigerant mixtures on refrigeration system capacity and components. This objective was accomplished by a succession of tasks, identified below.

### 1. Task I: Search The Literature

Recent literature was reviewed to identify various azeotropic refrigerant mixtures and to locate needed experimental data on both azeotropic and nonazeotropic refrigerant mixtures (binary interaction coefficient for each binary pair). The goal was to identify the needed data on as many mixtures as possible.

### 2. Task II: Determine The Impact Of Refrigerant Mixtures On Refrigeration System Components

Literature was surveyed to determine the various material compatibility characteristics of pure refrigerants and refrigerant mixtures. The goal of this task was to identify any pure refrigerants and refrigerant mixtures that will have an adverse effect on refrigeration system components.

### 3. Task III: Model Azeotropic Refrigerant Mixtures In Various Refrigeration Systems

The various azeotropic refrigerant mixtures identified in Tasks I and II were modeled in a refrigeration system using an equation of state. The predicted performance of the refrigerant mixture in the system was compared to the baseline pure refrigerant. The goal was to identify suitable azeotropic refrigerant mixtures.

### 4. Task IV: Model Nonazeotropic Refrigerant Mixtures In Various Refrigeration Systems

The various nonazeotropic refrigerant mixtures identified were modeled in a refrigeration system using an equation of state. The predicted performance of the refrigerant mixture in the system was compared to the baseline pure refrigerant. The goal was to identify suitable nonazeotropic refrigerant alternatives.

### 5. Task V: Recommend Future Work

This goal of this task was to identify and recommend specific tasks to be undertaken in Phase II of this research.

## B. BACKGROUND

Proper operation of the air-conditioning systems at Air Force bases is essential in the event of a military attack on an Air Force base. Such an attack could result in a loss of refrigerant in the air-conditioning system, resulting in system failure. The normal procedure would be to repair the damage and recharge the air-conditioner with the system (baseline) refrigerant. However, the baseline refrigerant may not always be available during such an attack. The only refrigerant available for recharging the system may be different from the baseline refrigerant. Thus, it is essential to know the impact of using mixed refrigerants on air-conditioning system capacity. Having this knowledge would allow for selection of the proper refrigerant alternative, if the original refrigerant is unavailable.

Mainstream Engineering Corporation analyzed various refrigerant mixtures in two different air-conditioning systems, using an equation of state to predict the thermodynamic properties. This study determined the change in capacity (evaporator heat load) as a function of mixture type and mixture concentration. The impact of these refrigerant mixtures on air-conditioning system components was also addressed.

## C. SCOPE/APPROACH

### 1. The Status Of Refrigerant Mixtures

Over the last several years the use of refrigerant mixtures as working fluids in refrigeration has been receiving much attention. Both azeotropic and nonazeotropic refrigerant mixtures have been investigated to meet the ever-increasing refrigeration system requirements because of their inherent advantages.

Azeotropic mixtures are those mixtures whose total pressure curve exhibits a maximum or minimum when plotted as a function of mixture composition (at constant temperature). It is this extreme point in the total pressure curve that defines the azeotropic composition of the mixture. As long as the composition remains at this point the fluid behaves thermodynamically like a pure fluid. Azeotropic refrigerant mixtures are used in systems in which certain properties of standard refrigerants need to be modified, or when boiling point properties different from those of the standard refrigerants are required. For example, R-500 is an azeotropic mixture of R-12 and R-152a. This mixture has a 20% capacity increase over R-22 (different boiling point property) and suppresses the flammability of R-152a (modification of standard refrigerant property)(1).

Nonazeotropic mixtures are those mixtures whose total pressure curve does not pass through an extreme value when plotted as a function of mixture composition (at constant temperature). Nonazeotropic refrigerant mixtures differ from pure refrigerants and azeotropic refrigerant mixtures in two important ways(2):

1. A constant pressure liquid-vapor phase change will occur over a temperature range, as opposed to pure and azeotropic systems, which have an isothermal constant pressure liquid-vapor phase change.

2. The equilibrium composition of the vapor and liquid phases are different, as opposed to pure and azeotropic systems, which have equal vapor and liquid compositions at equilibrium.

Both of the above-mentioned characteristics of nonazeotropic refrigerant mixtures can be used to improve the refrigeration system(1, 2). Utilization of the non-isothermal phase-change can result in improvement of the coefficient of performance of the cycle. Utilization of the composition difference at equilibrium can result in a capacity shift of the refrigeration system.

To improve the coefficient of performance of a refrigerant cycle, one would want to minimize the normal heat transfer penalties. One way to do this is to minimize the temperature difference between the entering temperature of the outside fluids at the heat source and heat sink (which for the real world are rarely isothermal). For isothermal phase-change fluids (i.e., pure refrigerants), the actual condensing and evaporating temperatures are dictated by the maximum heat sink temperature and the minimum heat source temperature. This can result in much higher thermodynamic lifts than if the average sink and source temperatures are used(3). The temperature profiles for a hypothetical isothermal refrigeration cycle are shown in Figure 1.

If a non-isothermal phase change fluid (i.e., a nonazeotropic refrigerant mixture) is used in the cycle, the temperature profiles of the refrigerant mixture can more closely resemble the heat sink and source temperature profiles. This will result in higher average evaporator temperatures and lower average condenser temperatures. This will lower the thermodynamic lift of the cycle and raise the potential coefficient of performance(3). A counterflow heat exchanger at the heat source and heat sink is required for this type of cycle. The temperature profiles for a hypothetical nonazeotropic refrigerant cycle are shown in Figure 2.

The utilization of the concentration difference between the equilibrium vapor and liquid phases of nonazeotropic refrigerant mixtures can result in the ability of the refrigeration system to change its capacity as the heat rejection temperature changes. This can be accomplished by adding a refrigerant component to, or taking a refrigerant component away from, the circulating refrigerant mixture. Extraction of the refrigerant with the highest boiling point may be needed to increase the system capacity if heat rejection temperatures are low. This can be done by collecting non-vaporized liquid in an accumulator, located in the compressor suction line. This collected liquid has the highest

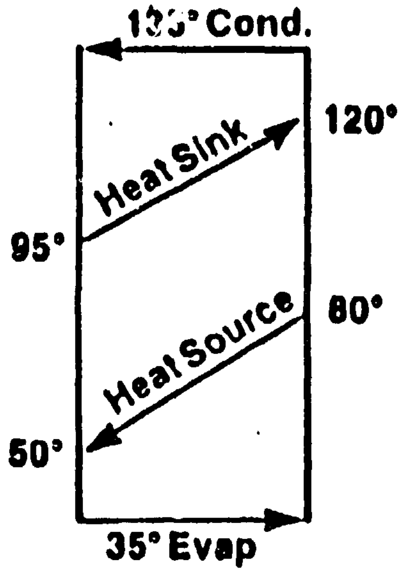


**FIGURE 1. HYPOTHETICAL ISOTHERMAL PURE REFRIGERANT CYCLE(2)**

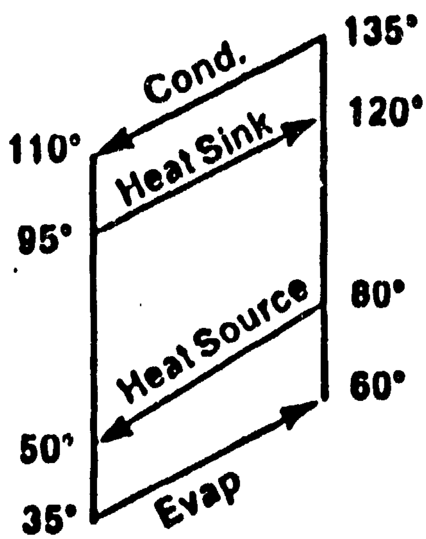


**FIGURE 2. HYPOTHETICAL NONAZEOTROPIC REFRIGERANT MIXTURE CYCLE(2)**

concentration of the highest-boiling refrigerant of any stream in the cycle. As the heat rejection temperature increases, the accumulator liquid will vaporize, re-entering the system. Similarly, the lowest-boiling refrigerant may need to be removed if the heat rejection temperature increases. This refrigerant component is removed as un-condensed vapor at the condenser outlet. It is at this location that the concentration of lowest-boiling refrigerant is the highest(1).

## 2. Refrigerants To Be Studied

Tyndall AFB personnel supplied Mainstream with a list of refrigerants to be considered under this contract. These refrigerants, their chemical name, and chemical formula are given in Table 1. The original list supplied by Tyndall AFB contained R-502, which is an azeotropic mixture of R-22 and R-115. Therefore, R-115 is listed in the table, rather than R-502.

**TABLE 1. REFRIGERANTS CONSIDERED UNDER THIS CONTRACT**

| REFRIGERANT NAME | CHEMICAL NAME | CHEMICAL FORMULA |
|---|---|---|
| R-11 | trichlorofluormethane | $CCl_3F$ |
| R-12 | dichlorodifluoromethane | $CCl_2F_2$ |
| R-13B1 (Halon 1301) | bromotrifluormethane | $CBrF_3$ |
| R-22 | chlorodifluoromethane | $CHClF_2$ |
| R-114B2 (Halon 2402) | dibromotetrafluoroethane | $CBrF_2CBrF_2$ |
| R-115 | chloropentafluoroethane | $CClF_2CF_3$ |
| R-50 | methane | $CH_4$ |
| R-290 | propane | $CH_3CH_2CH_3$ |
| R-728 | nitrogen | $N_2$ |
| R-732 | oxygen | $O_2$ |
| Halon 1211 | bromochlorodifluoromethane | $CBrClF_2$ |

## 3. Air-Conditioning System Operating Parameters

Personnel at Tyndall AFB have identified two baseline air-conditioning systems for a study on the impact of using mixed refrigerants in air-conditioning systems. This information was supplied to Mainstream via facsimile on 6 September 1989. Preliminary calculations by Mainstream engineers determined that the energy balance for the R-11 baseline system supplied in the fax of September 6, 1989 was slightly incorrect. According to the ASHRAE tables(4), if 100 kW is supplied to the compressor, the evaporator heat load is 430 kW instead of the 500 kW listed on the fax (for the given operating temperatures). Therefore the coefficient of performance for cooling (COPc) and evaporator heat load for the R-11 base system is lower than specified in the fax. The various parameters of these systems are given in Table 2.

**TABLE 2. BASELINE AIR-CONDITIONING SYSTEMS USED FOR THIS PROJECT**

| PARAMETER | SMALL (50 kW SYSTEM) | LARGE (430 kW) SYSTEM |
|---|---|---|
| Refrigerant | R-22 | R-11 |
| Mass Flow Rate | 0.303 kg/s | 3.087 kg/s |
| Evaporator Type | Shell-and-tube Water Chiller (Both Systems) | |
| Evaporator Inlet | 2°C | 2°C |
| Evaporator Outlet | 7°C | 7°C |
| Compressor Type | Reciprocating | Centrifugal |
| Compressor Eff. | 75 % | 80 % |
| Compressor Outlet | 82°C | 61°C |
| Condenser Load | 62.5 kW | 530 kW |
| Condensing Temp | 50°C | 50°C |
| Condenser Outlet | 35°C | 35°C |
| Expansion Device | Superheat-Controlled TXV (Both Systems) | |

# SECTION II

# MODELING TECHNIQUE

Mainstream developed a heat pump computer simulator to predict the change in cooling capacity as a function of refrigerant concentration. The simulator was designed to hold many of the system parameters equal to those of the baseline system. For example, the condenser saturation temperature was taken as 50°C and its outlet was assumed to be 35°C. The condenser pressure was taken as the bubble pressure of the mixture at 50°C. Similarly, the evaporator outlet temperature was held at 7°C by the expansion device, which controls the evaporator pressure. The compressor isentropic efficiency was also held to the baseline value. The heat pump computer simulator source code developed by Mainstream (FORTRAN-77) is included in Appendix C.

## A. THERMODYNAMIC PROPERTY PREDICTION

Mainstream selected the Carnahan-Starling-Desantis (CSD) equation of state to predict the thermodynamic properties of refrigerant mixtures. This equation of state and associated thermodynamic property routines were developed by the National Bureau of Standards for predicting the thermodynamic properties of refrigerants and refrigerant mixtures(5). The CSD equation of state accurately models both the vapor and liquid phases. Mainstream has implemented these subroutines for use in the heat pump computer simulator.

## B. COMPRESSOR MODEL

The compressor of the heat pump simulator was modeled as a positive displacement machine that supplies a constant volumetric flow rate of refrigerant. Most compressors have an AC power supply and their speed is a function of the frequency of the power source (for example, a compressor operating from a 60 Hz power source rotates at about 1725 rpm). As a result, a positive displacement compressor will operate at constant volumetric flow rate. The power supplied to the compressor will vary to accommodate the flow.

The volumetric flow rate and mass flow rate through the small-system compressor and large-system compressor were calculated based upon the baseline system operating parameters. The baseline refrigerant mass flow rate multiplied by the specific volume of the baseline refrigerant entering the compressor yielded the volumetric flow rate of the compressor, which was held constant. When the refrigerant concentration was different than the baseline system, the refrigerant mass flow rate changed because the specific volume of the refrigerant mixture was different than the baseline refrigerant (most likely). Thus, a new mass flow rate was calculated whenever the refrigerant concentration changed.

As the refrigerant concentration in the system changed, the new refrigerant mass flow rate was calculated by dividing the compressor volumetric flow rate by the specific volume of the vapor entering the compressor. The power required by the compressor was then calculated by multiplying the mass flow rate of the refrigerant and the enthalpy change of the refrigerant through the compressor (the specific enthalpy and entropy of the refrigerant at the compressor inlet were known and the specific enthalpy of the refrigerant at the compressor outlet was calculated based on the evaporator outlet entropy, condenser pressure, and the isentropic efficiency of the baseline compressor). Thus, both the refrigerant mass flow rate and the enthalpy difference through the compressor changed when refrigerant concentration changed.

The change in refrigerant mass flow rate and enthalpy difference through the compressor affect the compressor power requirement, as well. If a more-dense refrigerant is added to the system the mass flow rate of refrigerant will increase, which could result in an increase in the compressor power requirement over the baseline system. If the enthalpy difference through the compressor increases as a refrigerant is added, the compressor power requirement may also increase. This additional power requirement will cause motor failure or will cause the thermal overload control of the unit to shut the compressor off. Conversely, if a less-dense refrigerant is in the system the mass flow rate of refrigerant will decrease, which could result in a decrease in the compressor power requirement over the baseline system. The compressor power could also decrease if the enthalpy difference through the compressor decreased as a result of adding a secondary refrigerant. This decrease in the compressor power requirement may result in a decrease in system capacity.

Mainstream also modeled the compressor as a constant power machine rather than a constant volumetric flow rate machine. Constant power operation of a positive displacement machine can be achieved by supplying the compressor with power from a DC motor (rather than AC) or by varying the speed of the compressor to change its power requirement. These modeling results are contained in Appendix D.

## C. EXPANSION DEVICE

Mainstream modeled the expansion device in the heat pump cycle two ways, one using a generic expansion device and the other using a superheat-controlled thermostatic expansion valve (TXV). Mainstream took this approach because the TXV could play an important role in the cycle performance when the cycle working fluid is changed. These expansion devices control the evaporator pressure. Using a generic expansion device, it was assumed that the device maintains a constant evaporator outlet superheat of 5°C by setting the evaporator pressure to the dew pressure of the mixture at 2°C (evaporator saturation temperature). This allowed Mainstream to model the heat pump to the specifications of the baseline system, maintaining the same temperature lift.

An actual TXV operates differently, however. The TXV bulb is always charged with the same working fluid as the baseline cycle. The saturation properties of the working fluid in the bulb determine the evaporator pressure and thus control the evaporator outlet superheat and evaporator saturation temperature. Thus, if the working fluid in the cycle changes, the saturation properties of the working fluid in the cycle and in the bulb would be independent of one another. The TXV sets the same evaporator pressure as the baseline system, but this pressure would have a different saturation temperature for the cycle fluid mixture because it would be different from the TXV fluid. Because of this, the calculated evaporator outlet superheat will be different from that of the baseline system. This could significantly affect system capacity and performance; it could even result in a system that cannot operate at the baseline conditions (i.e., if the evaporator outlet is a saturated vapor/liquid mixture or a subcooled liquid).

**1. The Generic Approach**

In the generic approach, the change in cooling capacity was predicted as a function of refrigerant concentration (mol fraction of parent refrigerant) while holding many of the system parameters equal to those of the baseline system. The evaporator outlet temperature was held at 7°C while maintaining a constant evaporator outlet superheat of 5°C (evaporator saturation temperature held to 2°C). Thus, for the generic case, the system high- and low-side pressures must be allowed to vary to maintain the specified system temperatures as refrigerant concentration changes.

For example, consider the extreme cases of a baseline system of pure R-11, then R-12 is slowly added to the system, and finally the system consists of pure R-12. For the case of pure R-11, the low-side pressure will be the saturation pressure of R-11 at 2°C (43.6 kPa). As R-12 is added to the system, the low-side pressure is forced to increase in order to maintain the required superheat. When the system is completely recharged with R-12, the low-side pressure has magically risen to 318.0 kPa. Classically, this is the manner in which the performance of heat pump systems using non-azeotropic blends is predicted.

Unfortunately, the simplistic generic approach does not predict the performance truly indicative of a system with a real, as opposed to generic, metering device. The primary controller in the heat pump system is a TXV. The TXV is a hermetically sealed device that meters the refrigerant to the evaporator using a thermal sensing element to monitor the superheat. For typical systems, the valve is set (via spring preload) to provide a constant superheat at the evaporator outlet (typically around 5°C). The most commonly used TXV is the liquid charge bulb TXV in which the valve sensing element contains the same fluid as the system working fluid. These valves are extremely reliable and predictable when the system fluid is the same as the sensor fluid. However, when a different fluid is added to the system without changing the

TXV, the system may respond in an unfavorable manner. The second modeling technique, the TXV approach, was implemented to determine exactly what the system response would be as a secondary fluid was added to the system without replacing the metering device.

### 2. The TXV Approach

The TXV model varies from the generic model in one very pronounced fashion. The TXV model places absolutely no restrictions on the evaporator outlet superheat, whereas the generic model always restricts the superheat to 5°C. In the TXV model, the evaporator outlet temperature is assumed to be at 7°C for all cases. The metering device is a TXV charged with the same fluid as the baseline system. For example, a system originally charged with R-22 has a TXV charged with R-22 at all times, even when the R-22 in the system has been completely replaced with another fluid. This will cause the superheat to vary as a function of concentration, because the TXV's saturation properties and the system's saturation properties are no longer the same.

To better illustrate the change in superheat, consider the following discussion. Assume that a baseline system is originally charged with R-12 and contains a liquid charge bulb TXV that is preloaded to provide 5°C of superheat. Also assume that the evaporator outlet temperature is held at 7°C. For such a system, the low-side pressure is the saturation pressure of the TXV bulb fluid, R-12, at 7°C (384.5 kPa) minus the spring preload. This difference comes to approximately 325.0 kPa. Now assume that the TXV parameters and the evaporator outlet temperature remain the same, but the R-12 in the system has been replaced with R-11. This system will have the same low-side pressure as the original system (because the TXV and outlet temperature are the same). Thus, at equilibrium, the low side of this system contains R-11 at approximately 325.0 kPa. From an R-11 saturation table, the saturation temperature at 325.0 kPa equals 61.0°C. However, the evaporator outlet temperature is held at 7°C. Therefore, the evaporator outlet is 54°C **subcooled**. This will cause almost immediate failure of the compressor due to massive liquid slugging, and the system obviously will not function.

A similar phenomena holds for fluid mixtures. In general, fluid mixtures do not exhibit one distinct boiling point, rather they exhibit a gliding boiling range. At a fixed pressure and concentration, the heating of a saturated liquid will result in the onset of boiling. The first temperature at which bubbles start to form is referred to as the bubble point. As heat is added, the fluid continues boiling and the temperature also keeps increasing. When the last bit of liquid has boiled off, the fluid has reached the dew point. These bubble and dew points may differ anywhere from 0.0°C (for the rare azeotropic mixture) to over 100°C for some fluid mixtures. With this in mind, consider again the above system, but instead of recharging the system completely with R-11, add 50 wt percent R-11 to the system. Thermodynamic properties of 50-50 mixtures of R-11 with R-12 reveal the dew temperature of the

mixture to be approximately 42.0°C. For such a refrigeration system, a 50-50 mixture of R-11 and R-12 results in an evaporator outlet temperature 35.0°C below the dew temperature, making compressor slugging again a major concern.

Anothe. ior concern is excessive superheat at the evaporator outlet. Tl phenomena will occur if the dew temperature of the refrigerant mixture is below 0°C. For example, if the desired evaporator outlet temperature is 7°C and steady-state operation of the TXV requires more than 7°C of superheat, the mixture dew point must be below 0°C. This will cause the water in the chiller to freeze, forming an insulating layer on the evaporator that limits heat transfer and cooling capability. As a result, evaporation is limited, which may again cause slugging of the compressor. If antifreeze is used in the water chiller, a lower mixture dew temperature can be tolerated.

### 3. Impact Of Two Approaches On Modeling Results

The above examples illustrate the importance of the TXV modeling approach. None of the information about varying superheat and liquid slugging is available from the generic model. This generic model only predicts the change in performance of the system if all other conditions are magically adjusted to allow the system to operate at a constant superheat. In reality, though, this is not practical. The TXV approach is the only modeling technique available that will yield results truly indicative of the system performance and behavior.

The approach used to model the expansion device also has an impact on the predicted performance of the system. Figure 3 shows a plot of COPc versus mixture concentration for the azeotropic mixture R-22/R-502, while Figure 4 shows a plot of COPc versus mixture concentration for the nonazeotropic mixture R-22/R-13B1. As Figure 3 shows, there is a dramatic difference in the COPc between the two approaches. The COPc of the cycle is more dependent on the mixture concentration for the TXV approach than for the generic approach. This difference is due to the fact that the thermodynamic lift of the cycle is unchanged with the generic approach while the thermodynamic lift of the cycle changes with the TXV approach. The generic approach maintains a constant superheat no matter what the refrigerant concentration, maintaining the same thermodynamic lift in the cycle. The TXV approach changes the thermodynamic lift because the evaporation saturation temperature changes as the refrigerant concentration changes. This change in evaporator saturation temperature has a dramatic affect on COPc, which varies inversely with thermodynamic lift. Figures 5 and 6 show how system capacity varies with the modeling technique and mixture concentration for the R-22/R-502 and R-22/R-13B1 systems. Figures 5 and 6 show that the TXV approach and the generic approach give varying results, illustrating the significance of using the most appropriate modeling technique. These results were taken from Tables 7 and 9 of Section III, Results and Discussion.

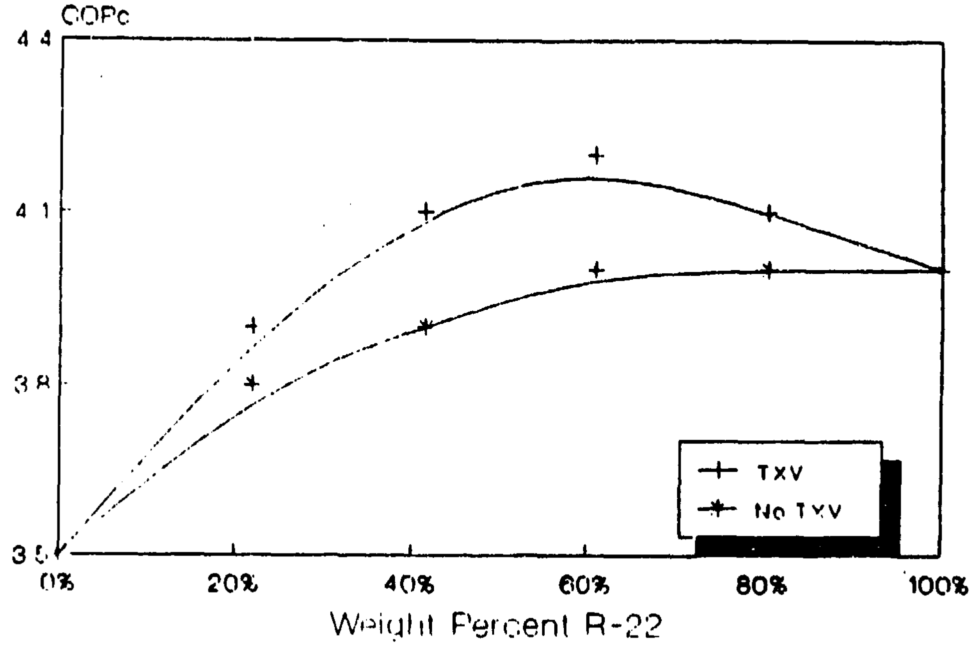


**FIGURE 3. PLOT OF COPc VERSUS CONCENTRATION FOR AZEOTROPIC MIXTURE R-22/R-502.**

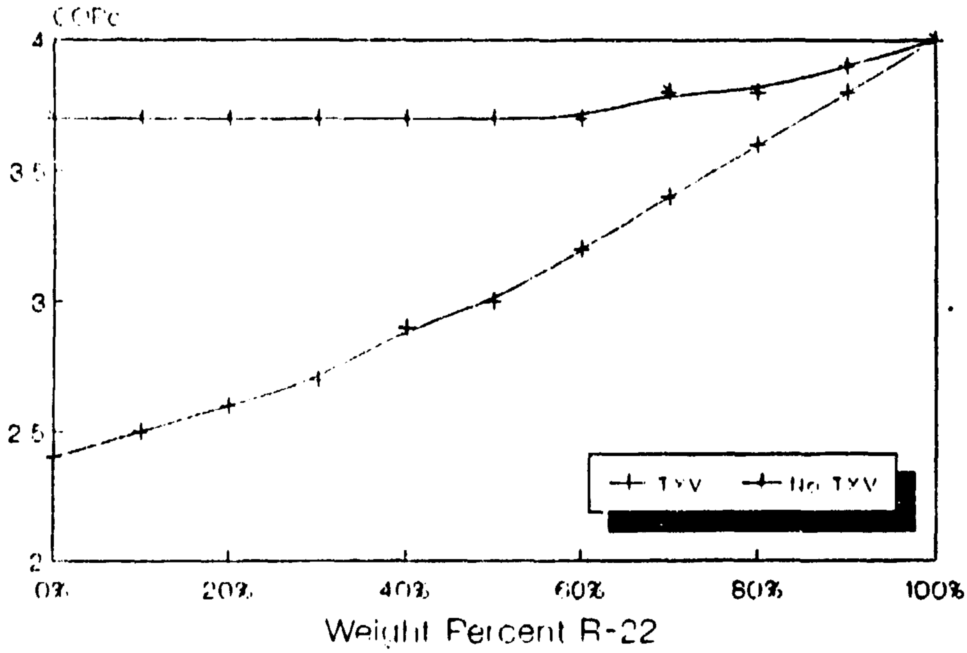


**FIGURE 4. PLOT OF COPc VERSUS CONCENTRATION FOR NONAZEOTROPIC MIXTURE R-22/R-13B1.**

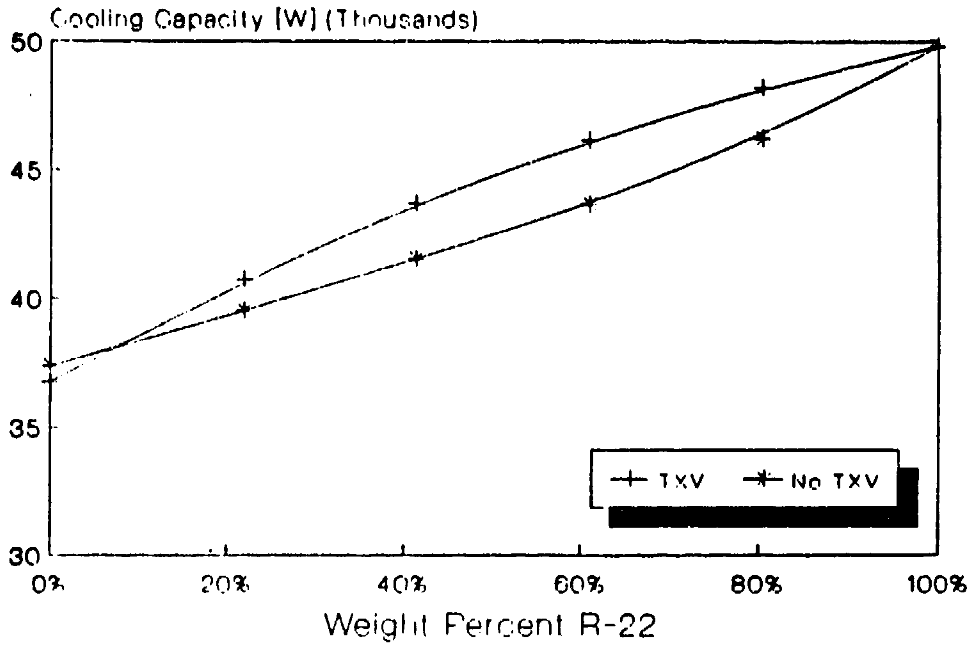


**FIGURE 5. PLOT OF SYSTEM CAPACITY VERSUS CONCENTRATION FOR AZEOTROPIC MIXTURE R-22/R-502.**

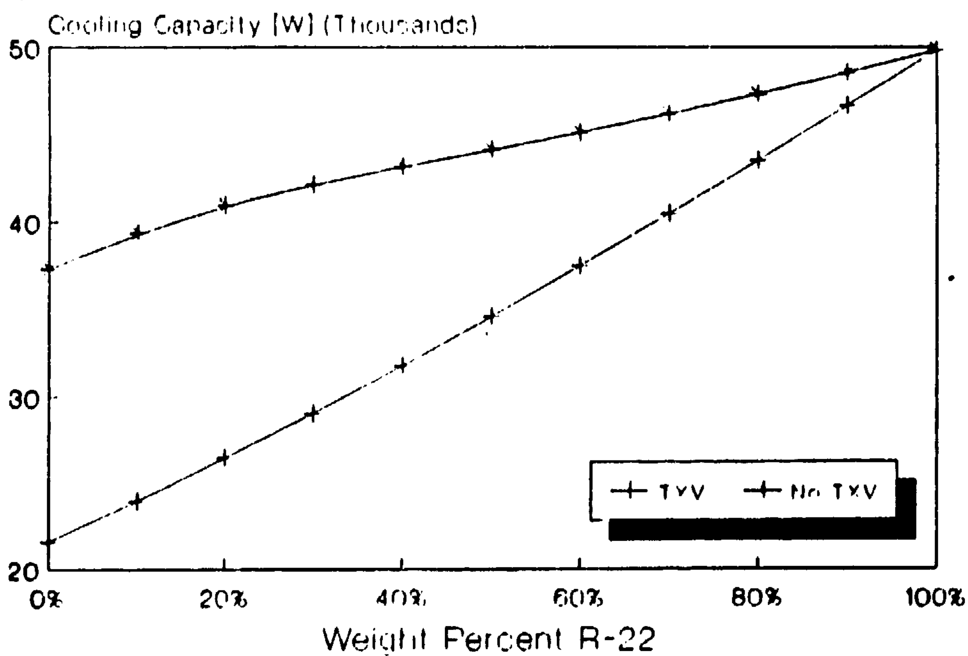


**FIGURE 6. PLOT OF SYSTEM CAPACITY VERSUS CONCENTRATION FOR NONAZEOTROPIC MIXTURE R-22/R-13B1.**

# SECTION III

# RESULTS AND DISCUSSION

This section will present the results obtained in each of the tasks performed under this contract. A discussion of the impact of the results is also included in this section.

## A. TASK I: SEARCH THE LITERATURE

The refrigerants to be considered under this contract are listed in Table 1. Two things should be noted from this table. First, R-502 is an azeotropic mixture of R-22 and R-115; therefore R-115 is listed in the table rather than R-502. Second, some of the Halon compounds also have *ASHRAE* refrigerant designations, namely, Halon 1301 is R-13B1 and Halon 2402 is R-114B2.

Mainstream contacted Dr. Mark McLinden of the National Bureau of Standards in an effort to determine the best source for experimental vapor-liquid equilibrium data for refrigerant mixtures (see Appendix B). Dr. McLinden suggested searching *Chemical Abstracts*, using the actual chemical name as the search topic. Dr. McLinden stated that any experimental data published would be referenced in *Chemical Abstracts*. Dr. McLinden's research areas include the evaluation of working fluids in refrigeration systems.

Mainstream conducted a literature search for refrigerant mixture data by searching *Chemical Abstracts* for trichlorofluormethane (R-11) and chlorodifluoromethane (R-22). The dates searched were from the first volume of *Chemical Abstracts* (1907) to the current volume (1989). A summary of the results of this literature search is given in Table 3. As Table 3 shows, there is a lot of mixture data available concerning R-22, but very little data concerning R-11.

During a telephone conversation with Halon manufacturers (see Appendix B), it was stated that Halon 2402 is a Japanese product no longer in production and the thermodynamic data for this product is difficult to obtain. Although Mainstream obtained data on the mixture R-114B2/R-22, we were unable to find any of the pure component data on R-114B2 that is required by the equation of state. Therefore, we were unable to model pure R-114B2 or any mixture containing R-114B2.

## TABLE 3. RESULTS OF LITERATURE SEARCH

| | R-11 | R-22 |
|---|---|---|
| R-11 | ---- | Binary Coef. Known |
| R-12 | Binary Coef. Known | Binary Coef. Known |
| R-13B1 | No Data Available | Binary Coef. Known |
| R-22 | Binary Coef. Known | ---- |
| R-114B2 | No Data Available | Data Source Obtained* Requires Translation |
| R-115 | No Data Available | Binary Coef. Known |
| R-50 | No Data Available | Data Source Obtained (Outside EOS Range) |
| R-290 | No Data Available | Binary Coef. Known |
| R-728 | No Data Available | Data Source Obtained (Outside EOS Range) |
| R-732 | No Data Available | No Data Available |
| H-1211 | No Data Available | No Data Available |

* See comments in text concerning R-114B2

The binary interaction coefficient for the pairs R-11/R-12, R-11/R-22, R-12/R-22, and R-22/R-13B1 were found in the literature concerning the CSD equation of state(5). Mainstream has determined the binary interaction coefficient for the remaining refrigerant pairs for which the data could be obtained. The value of this coefficient was determined by minimizing the error between experimental and predicted bubble pressures. For the pair R-22/R-115, literature data(6) yielded a value of -0.277 for the binary interaction coefficient. For the pair R-22/R-290, experimental data(7) yielded a value of 0.072 for the binary interaction coefficient. Experimental data for the pairs R-22/R-50(8) and R-22/R-728(9) were at temperatures and pressures that were above the critical point of either methane (R-50) or nitrogen (R-728). Because of this, the CSD equation of state was unable to predict the two-phase data for these super-critical conditions. Thus, Mainstream was unable to determine a binary interaction coefficient for R-22/R-50 and R-22/R-728.

For those refrigerant pairs where no data is available, it is possible to assume a binary interaction coefficient for a binary pair (0.0 for the CSD equation of state). Mainstream performed a sensitivity analysis on the pair R-11/R-12 that showed that the predicted capacity of the system is a strong function of the value of the binary interaction coefficient.

Table 4 shows the results of this sensitivity analysis for the R-11 base system with the R-11/R-12 mixture. Evaporator heat loads were determined for the R-11 base system (TXV modeling approach) with R-12 as the secondary refrigerant. The binary interaction coefficient was varied from its correct value of 0.005 to -0.05 and 0.05. As the table shows, the evaporator heat load is a strong function of the value of the binary interaction coefficient, even if the coefficient is only slightly adjusted. The data in Table 1 show maximum errors as high as 12.8 percent. Thus, Mainstream determined it was not feasible to assume a value of 0.0 for any pair that experimental data could not be obtained.

**TABLE 4. SENSITIVITY ANALYSIS ON BINARY INTERACTION COEFFICIENT**

| | EVAPORATOR HEAT LOAD (W) | | |
|---|---|---|---|
| | $f_{12}$ = 0.005 | $f_{12}$ = -0.05 | $f_{12}$ = 0.05 |
| 100.0 wt% R-11 | 429,779. | 429,779. | 429,779. |
| 90.0 wt% R-11 | 332,596. | 364,292. | 305,705. |
| 80.0 wt% R-11 | 280,220. | 315,177. | 253,942. |
| 70.0 wt% R-11 | 245,480. | 276,799. | 222,791. |
| 60.0 wt% R-11 | 219,778. | 245,882. | 200,867. |
| 50.0 wt% R-11 | 199,450. | 220143. | 184,067. |
| 40.0 wt% R-11 | 182,639. | 198,372. | 170,521. |
| 30.0 wt% R-11 | 168,290. | 179,548. | 159,250. |
| 20.0 wt% R-11 | 155,748. | 162,970. | 149,684. |
| 10.0 wt% R-11 | 144,570. | 148,094. | 141,496. |
| 0.0 wt% R-11 | 134,471. | 134,471. | 134,471. |

Base Refrigerant: R-11 Secondary Refrigerant: R-12
TXV Modeling Approach
Actual value of binary interaction coefficient: 0.005

## B. TASK II: DETERMINE THE IMPACT OF REFRIGERANT MIXTURES ON REFRIGERANT SYSTEM COMPONENTS

Some general trends have been identified concerning refrigeration system lubricants, refrigerant chemistry, and the interaction of system lubricants with the refrigerants. This information was obtained through the *1980 ASHRAE Systems Handbook*(10).

Refrigeration system lubricants fall into four general categories: paraffins, napthenes, aromatics, and non-hydrocarbons. Paraffins (noncyclic, saturated hydrocarbons) and napthenes (cyclic, saturated hydrocarbons) offer good stability but have poor solubility in polar refrigerants and are poor boundary lubricants. Straight-chained paraffins are typically not used in refrigeration systems due to their high pour point, which causes wax precipitation in the system. Aromatics (cyclic hydrocarbons with alternating double bonds) are more reactive but have good solubility in refrigerants and offer good boundary lubrication. Non-hydrocarbons (molecules with elements other than carbon and hydrogen) are the most reactive but also have good solubility and lubrication characteristics. Synthetic oils, such as the alkylbenzenes, have been found to be completely satisfactory as refrigeration system lubricants.

Several trends have also been identified in terms of refrigerant/oil reactivity. Reactions between the oil and refrigerant are undesirable because the reaction products can cause a reduction in system capacity or system failure. Hydrocarbon refrigerants generally pose no stability problems in the presence of lubricants. For the chlorofluorocarbons, substituting fluorine for chlorine decreases reactivity, substituting hydrogen for chlorine decreases reactivity, and substituting fluorine for hydrogen decreases reactivity.

Mainstream contacted Pete Narreau of the Carlyle Compressor Division of Carrier Corporation (see Appendix B) in an effort to get some information concerning compressor lubricants, and what happens when a leak occurs. Mr. Narreau stated that only a small amount of oil (1-3 percent) is actually circulated in the refrigeration cycle; the majority of the oil is in the compressor crankcase and oil separator. Therefore, a leak in the system will not result in a critical loss of oil **unless** the leak is in the crankcase of the compressor, in an oil trap, or in an oil separator. Thus, the decision to replace oil is totally dependent upon the location of the leak, the severity of the leak, and how long the system was run after the leak occurred. If the leak results in compressor failure, the oil must be checked and the compressor tested. A large leak in the system may also allow moisture to collect in the oil, which may force replacement of the oil.

Mainstream also addressed the issue of refrigerant mixture flammability, and feels that the mixture R-22/R-290 may possess some degree of flammability due to the presence of R-290 (propane). None of the other refrigerants posses any flammability properties due to their high halogen content(11). The Halon compounds are also well-known for their use in fire extinguishing applications(12).

## C. TASK III: MODEL AZEOTROPIC REFRIGERANT MIXTURES IN VARIOUS REFRIGERATION SYSTEMS

Mainstream has identified three binary azeotropic mixtures out of all the possible binary pairs to be considered. These azeotropic binaries are R-12/R-22 (R-501), R-22/R-115 (R-502), and R-22/R-290.

### 1. Small System: R-22 Base Refrigerant

Tables 5-7 show the results of modeling the pairs R-22/R-12, R-22/R-115, and R-22/R-290. Tables of the thermodynamic properties of these refrigerants are given in Appendix A. Table 5 shows the affect of refrigerant concentration on the R-22/R-12 system parameters.

For the TXV approach, Table 5 shows that the refrigerant mass flow rate increased with increasing R-12 concentration since R-12 is the more-dense fluid. This increase in mass flow rate resulted in lower compressor work, however, because the enthalpy difference through the compressor decreased (the condenser pressure decreased). System capacity decreased with increasing R-12 concentration as a result of the decrease in compressor work. The table shows that the evaporator superheat also decreased with increasing R-12 concentration. This resulted in an increase in system COPc since the thermodynamic lift of the cycle decreased. At about 60 wt% R-12, however, the outlet superheat became negative (the dew temperature rose above 7°C) causing liquid slugging in the compressor. Thus, the system should not be operated if the R-12 concentration exceeds 60 wt%.

For the generic approach, Table 5 shows that the low-side pressure decreased with increasing R-12 concentration (R-12 is less-volatile than R-22). The generic approach maintained constant thermodynamic lift (constant evaporator superheat) so the COPc of the cycle changed little as concentration changed. The refrigerant mass flow rate through the compressor decreased because the specific volume of the refrigerant entering the compressor increased (the low-side pressure dropped). This decrease in mass flow rate resulted in a decrease in compressor work, lowering system capacity. The potential for liquid slugging in the compressor was not seen using the generic approach.

**TABLE 5. MODELING RESULTS FOR R-22/R-12 MIXTURE**

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 100.0 | 100.0 | High Pres (kPa) | 1933.3 | 1933.3 |
| | | Low Pres. (kPa) | 527.1 | 527.1 |
| | | Superheat (C) | 5.0 | 5.0 |
| | | Flow Rate (kg/s) | 0.2965 | 0.2965 |
| | | COPc | 4.0 | 4.0 |
| | | Compressor Work (W) | 12500. | 12500. |
| | | Q Evap (W) | 49823. | 49823. |
| | | % Capacity Change | ---- | ---- |
| 90.0 | 92.6 | High Pres (kPa) | 1924.1 | 1924.1 |
| | | Low Pres. (kPa) | 527.1 | 529.1 |
| | | Superheat (C) | 5.1 | 5.0 |
| | | Flow Rate (kg/s) | 0.2972 | 0.2985 |
| | | COPc | 4.0 | 4.0 |
| | | Compressor Work (W) | 12051. | 12058. |
| | | Q Evap (W) | 47804. | 47996. |
| | | % Capacity Change | - 4.05 | - 3.67 |
| 80.0 | 84.8 | High Pres (kPa) | 1903.8 | 1903.8 |
| | | Low Pres. (kPa) | 527.1 | 526.2 |
| | | Superheat (C) | 4.9 | 5.0 |
| | | Flow Rate (kg/s) | 0.2979 | 0.2974 |
| | | COPc | 4.0 | 4.0 |
| | | Compressor Work (W) | 11550. | 11547. |
| | | Q Evap (W) | 45934. | 45852. |
| | | % Capacity Change | - 7.81 | - 7.97 |
| 70.0 | 76.5 | High Pres (kPa) | 1872.4 | 1872.4 |
| | | Low Pres. (kPa) | 527.1 | 516.9 |
| | | Superheat (C) | 4.4 | 5.0 |
| | | Flow Rate (kg/s) | 0.2988 | 0.2923 |
| | | COPc | 4.0 | 3.9 |
| | | Compressor Work (W) | 11002. | 10971. |
| | | Q Evap (W) | 44218. | 43305. |
| | | % Capacity Change | - 11.3 | - 13.1 |
| 60.0 | 67.7 | High Pres (kPa) | 1829.4 | 1829.4 |
| | | Low Pres. (kPa) | 527.1 | 500.3 |
| | | Superheat (C) | 3.3 | 5.0 |
| | | Flow Rate (kg/s) | 0.2999 | 0.2827 |
| | | COPc | 4.1 | 3.9 |
| | | Compressor Work (W) | 10407. | 10332. |
| | | Q Evap (W) | 42659. | 40349. |
| | | % Capacity Change | - 14.4 | - 19.0 |
| 50.0 | 58.3 | High Pres (kPa) | 1773.6 | 1773.6 |
| | | Low Pres. (kPa) | 527.1 | 477.2 |
| | | Superheat (C) | 1.8 | 5.0 |
| | | Flow Rate (kg/s) | 0.3011 | 0.2690 |
| | | COPc | 4.2 | 3.9 |

TABLE 5. MODELING RESULTS FOR R-22/R-12 MIXTURE (continued)

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 50.0 (continued) | 58.3 | Compressor Work (W) | 9764. | 9633. |
| | | Q Evap (W) | 41262. | 37097. |
| | | % Capacity Change | - 17.3 | - 25.5 |
| 40.0 | 48.2 | High Pres (kPa) | 1703.2 | 1703.2 |
| | | Low Pres. (kPa) | 527.1* | 449.2 |
| | | Superheat (C) | - 0.1* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.2524 |
| | | COPc | ---- | 3.8 |
| | | Compressor Work (W) | ---- | 8880. |
| | | Q Evap (W) | ---- | 33738. |
| | | % Capacity Change | ---- | - 32.3 |
| 30.0 | 37.5 | High Pres (kPa) | 1615.7 | 1615.7 |
| | | Low Pres. (kPa) | 527.1* | 418.7 |
| | | Superheat (C) | - 2.4* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.2344 |
| | | COPc | ---- | 3.8 |
| | | Q Evap (W) | ---- | 30455 |
| | | Compressor Work (W) | ---- | 8081. |
| | | % Capacity Change | ---- | - 38.9 |
| 20.0 | 25.9 | High Pres (kPa) | 1507.6 | 1507.6 |
| | | Low Pres. (kPa) | 527.1* | 387.5 |
| | | Superheat (C) | - 5.0* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.2160 |
| | | COPc | ---- | 3.8 |
| | | Compressor Work (W) | ---- | 7239. |
| | | Q Evap (W) | ---- | 27377. |
| | | % Capacity Change | ---- | - 45.1 |
| 10.0 | 13.4 | High Pres (kPa) | 1373.8 | 1373.8 |
| | | Low Pres. (kPa) | 527.1* | 356.8 |
| | | Superheat (C) | - 7.7* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.1981 |
| | | COPc | ---- | 3.9 |
| | | Compressor Work (W) | ---- | 6352. |
| | | Q Evap (W) | ---- | 24571. |
| | | % Capacity Change | ---- | - 50.7 |
| 0.0 | 0.0 | High Pres (kPa) | 1207.9 | 1207.9 |
| | | Low Pres. (kPa) | 527.1* | 327.4 |
| | | Superheat (C) | - 10.6* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.1812 |
| | | COPc | ---- | 4.1 |
| | | Compressor Work (W) | ---- | 5409. |
| | | Q Evap (W) | ---- | 22060. |
| | | % Capacity Change | ---- | - 55.7 |

* Compressor will fail due to slugging

Table 6 shows the modeling results for the pair R-22/R-115 (R-502). Since the Air Force stocks R-502 (an azeotropic mixture of R-22 and R-115), not R-115, Table 6 gives the results based on R-502 concentration. For example, a concentration of 80 wt% R-22 from Table 6 means 20 wt% R-502. However, the actual mixture concentrations are 89.8 wt% R-22 and 10.2 wt% R-115.

For the TXV approach the refrigerant mass flow rate increased with increasing R-502 concentration since R-502 is more dense than R-22. The compressor work, however, did not increase, which means the enthalpy difference through the compressor decreased. The decrease in compressor work with increasing R-502 concentration lowered system capacity. Table 6 shows the generic approach yielded similar results to the TXV approach. The generic approach, however, yielded lower mass flow rates with increasing R-502 concentration (except at 100% R-502). This is because the generic approach allowed the low-side pressure to decrease, increasing the specific volume of the fluid. For both the TXV and generic approach, the COPc of the system remained fairly constant until 100% R-502 was in the system, where it dropped to 3.5. Thus, Table 6 shows that R-502 is a suitable replacement for the R-22 system over the entire concentration range, resulting in a slight decrease in system capacity.

Table 7 presents the results from modeling the mixture R-22/R-290. As Table 7 shows, addition of R-290 to the R-22 system results in an increase in compressor work for both the TXV approach and the generic approach. For the TXV system, the increase in compressor work was due to an increase in the enthalpy difference through the compressor (the mass flow rate remained fairly constant). For the generic approach, the increase in compressor work was due to an increase in refrigerant mass flow rate. The mass flow rate increased because the low-side pressure increased, causing an decrease in the specific volume of refrigerant. The increase in compressor work will result in motor failure or will cause the thermal overload control of the unit to shut the compressor off. Thus, R-290 is not a suitable replacement in the R-22 system it will cause a power overload in the compressor.

It is interesting to note the equation of state predicts the presence of an azeotrope for all the azeotropic pairs. This can be seen by noticing that each of the azeotropic pairs has either a minimum or maximum in pressure at a concentration between the pure component concentrations (in other words, at a concentration greater than 0% and less than 100%). For each of the nonazeotropic pairs, however, the equation of state predicts the maximum and minimum pressures to be at the pure component concentrations (in other words, at 0% or at 100%). This is typical pressure behavior for azeotropic and nonazeotropic mixtures.

**2. Large System: R-11 Base Refrigerant**

There are no azeotropic mixtures of R-11 with the fluids to be considered under this contract.

TABLE 6. MODELING RESULTS FOR R-22/R-115 (R-502) MIXTURE

| MASS % R-22 | MASS% R-502 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 100.0 | 0.0 | High Pres (kPa) | 1933.3 | 1933.3 |
| | | Low Pres. (kPa) | 527.1 | 527.1 |
| | | Superheat (C) | 5.0 | 5.0 |
| | | Flow Rate (kg/s) | 0.2965 | 0.2965 |
| | | COPc | 4.0 | 4.0 |
| | | Compressor Work (W) | 12500. | 12500. |
| | | Q Evap (W) | 49823. | 49823. |
| 80.4 | 19.6 | High Pres (kPa) | 1904.1 | 1904.1 |
| | | Low Pres. (kPa) | 527.1 | 506.8 |
| | | Superheat (C) | 3.8 | 5.0 |
| | | Flow Rate (kg/s) | 0.2977 | 0.2848 |
| | | COPc | 4.1 | 4.0 |
| | | Compressor Work (W) | 11716. | 11643. |
| | | Q Evap (W) | 48198. | 46221. |
| | | % Capacity Change | - 3.26 | - 7.23 |
| 61.0 | 39.0 | High Pres (kPa) | 1902.3 | 1902.3 |
| | | Low Pres. (kPa) | 527.1 | 500.3 |
| | | Superheat (C) | 3.4 | 5.0 |
| | | Flow Rate (kg/s) | 0.2987 | 0.2817 |
| | | COPc | 4.2 | 4.0 |
| | | Compressor Work (W) | 11084. | 10989. |
| | | Q Evap (W) | 46161. | 43667. |
| | | % Capacity Change | - 7.35 | - 12.4 |
| 41.4 | 58.6 | High Pres (kPa) | 1946.5 | 1946.5 |
| | | Low Pres. (kPa) | 527.1 | 502.4 |
| | | Superheat (C) | 3.5 | 5.0 |
| | | Flow Rate (kg/s) | 0.2996 | 0.2838 |
| | | COPc | 4.1 | 3.9 |
| | | Compressor Work (W) | 10663. | 10572. |
| | | Q Evap (W) | 43679. | 41500. |
| | | % Capacity Change | - 12.3 | - 16.7 |
| 21.9 | 78.1 | High Pres (kPa) | 2056.5 | 2056.5 |
| | | Low Pres. (kPa) | 527.1 | 512.5 |
| | | Superheat (C) | 4.2 | 5.0 |
| | | Flow Rate (kg/s) | 0.3004 | 0.2910 |
| | | COPc | 3.9 | 3.8 |
| | | Compressor Work (W) | 10479. | 10419. |
| | | Q Evap (W) | 40714. | 39512. |
| | | % Capacity Change | - 18.3 | - 20.7 |

**TABLE 6. MODELING RESULTS FOR R-22/R-115 MIXTURE** (Concluded).

| MASS % R-22 | MASS% R-502 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 0.0 | 100.0 | High Pres (kPa) | 2282.0 | 2282.0 |
| | | Low Pres. (kPa) | 527.1 | 535.4 |
| | | Superheat (C) | 5.5 | 5.0 |
| | | Flow Rate (kg/s) | 0.3010 | 0.3064 |
| | | COPc | 3.5 | 3.5 |
| | | Compressor Work (W) | 10525. | 10566. |
| | | Q Evap (W) | 36760. | 37379. |
| | | % Capacity Change | - 26.2 | - 25.0 |

## TABLE 7. MODELING RESULTS FOR R-22/R-290 MIXTURE

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 100.0 | 100.0 | High Pres (kPa) | 1933.3 | 1933.3 |
| | | Low Pres. (kPa) | 527.1 | 527.1 |
| | | Superheat (C) | 5.0 | 5.0 |
| | | Flow Rate (kg/s) | 0.2965 | 0.2965 |
| | | COPc | 4.0 | 4.0 |
| | | Compressor Work (W) | 12500. | 12500. |
| | | Q Evap (W) | 49823. | 49823. |
| 90.0 | 82.1 | High Pres (kPa) | 2094.2 | 2094.2 |
| | | Low Pres. (kPa) | 527.1 | 583.5 |
| | | Superheat (C) | 8.2** | 5.0 |
| | | Flow Rate (kg/s) | 0.2966 | 0.3327 |
| | | COPc | 3.5 | 3.9 |
| | | Compressor Work (W) | 14476.# | 14732.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 80.0 | 67.1 | High Pres (kPa) | 2141.9 | 2141.9 |
| | | Low Pres. (kPa) | 527.1 | 621.0 |
| | | Superheat (C) | 10.3** | 5.0 |
| | | Flow Rate (kg/s) | 0.2970 | 0.3579 |
| | | COPc | 3.4 | 3.9 |
| | | Compressor Work (W) | 15901.# | 16347.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 70.0 | 54.3 | High Pres (kPa) | 2138.2 | 2138.2 |
| | | Low Pres. (kPa) | 527.1 | 631.6 |
| | | Superheat (C) | 10.9** | 5.0 |
| | | Flow Rate (kg/s) | 0.2975 | 0.3659 |
| | | COPc | 3.3 | 3.9 |
| | | Compressor Work (W) | 17054.# | 17568.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 60.0 | 43.3 | High Pres (kPa) | 2106.2 | 2106.2 |
| | | Low Pres. (kPa) | 527.1 | 620.7 |
| | | Superheat (C) | 10.4** | 5.0 |
| | | Flow Rate (kg/s) | 0.2982 | 0.3596 |
| | | COPc | 3.3 | 3.9 |
| | | Compressor Work (W) | 18022.# | 18505.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 50.0 | 33.8 | High Pres (kPa) | 2056.8 | 2056.8 |
| | | Low Pres. (kPa) | 527.1 | 600.0 |
| | | Superheat (C) | 9.3** | 5.0 |
| | | Flow Rate (kg/s) | 0.2990 | 0.3468 |
| | | COPc | 3.4 | 3.8 |
| | | Compressor Work (W) | 18842.# | 19234.# |

TABLE 7. MODELING RESULTS FOR R-22/R-290 MIXTURE (Concluded).

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 50.0 (continued) | 33.8 | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 40.0 | 25.4 | High Pres (kPa) | 1996.3 | 1996.3 |
| | | Low Pres. (kPa) | 527.1** | 576.9 |
| | | Superheat (C) | 8.0 | 5.0 |
| | | Flow Rate (kg/s) | 0.2998 | 0.3325 |
| | | COPc | 3.5 | 3.8 |
| | | Compressor Work (W) | 19530.# | 19804.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 30.0 | 17.9 | High Pres (kPa) | 1928.4 | 1928.4 |
| | | Low Pres. (kPa) | 527.1 | 554.9 |
| | | Superheat (C) | 6.7 | 5.0 |
| | | Flow Rate (kg/s) | 0.3006 | 0.3188 |
| | | COPc | 3.6 | 3.8 |
| | | Compressor Work (W) | 20095.# | 20246.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 20.0 | 11.3 | High Pres (kPa) | 1855.6 | 1855.6 |
| | | Low Pres. (kPa) | 527.1 | 534.9 |
| | | Superheat (C) | 5.5 | 5.0 |
| | | Flow Rate (kg/s) | 0.3013 | 0.3065 |
| | | COPc | 3.8 | 3.9 |
| | | Compressor Work (W) | 20540.# | 20580.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 10.0 | 5.4 | High Pres (kPa) | 1779.6 | 1779.6 |
| | | Low Pres. (kPa) | 527.1 | 517.1 |
| | | Superheat (C) | 4.4 | 5.0 |
| | | Flow Rate (kg/s) | 0.3021 | 0.2956 |
| | | COPc | 4.0 | 3.9 |
| | | Compressor Work (W) | 20865.# | 20817.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 0.0 | 0.0 | High Pres (kPa) | 1701.6 | 1701.6 |
| | | Low Pres. (kPa) | 527.1 | 501.4 |
| | | Superheat (C) | 3.3 | 5.0 |
| | | Flow Rate (kg/s) | 0.3029 | 0.2860 |
| | | COPc | 4.2 | 4.0 |
| | | Compressor Work (W) | 21070.# | 20964.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |

** Potential freezing in water chiller
# Compressor will fail due to power overload

## D. TASK IV: MODEL NONAZEOTROPIC REFRIGERANT MIXTURES IN VARIOUS REFRIGERATION SYSTEMS

All the remaining refrigerant pairs from Table 1 are nonazeotropic refrigerant mixtures over their concentration range.

### 1. Small System: R-22 Base Refrigerant

Two nonazeotropic refrigerant pairs have been modeled, the pairs R-22/R-11 and R-22/R13B1. Tables 8 and 9 show the modeling results for these pairs.

As Table 8 shows, R-11 is a poor candidate for mixing in an R-22 system controlled by an R-22 TXV. The significant difference in volatility of these two fluids results in a mixture dew temperature well above 7°C over the entire concentration range, resulting in compressor slugging due to liquid leaving the evaporator. Even when modeled using the generic approach, the addition of R-11 to the R-22 system results in a significant decrease in system capacity due to a significant decrease in refrigerant mass flow rate (the low-side pressure dropped increasing the specific volume of the refrigerant entering the compressor). The COPc also drops significantly with increasing R-11 concentration using the generic approach.

Table 9 shows the results of adding R-13B1 to the R-22 system. Using the TXV approach, the addition of R-13B1 to the system results in excess evaporator superheat because R-13B1 is more volatile than R-22. This higher volatility causes the evaporator saturation temperature to drop if the evaporator outlet temperature is maintained at 7°C. If the R-13B1 concentration is above 20 wt%, the potential for freezing the water in the water chiller exists because the evaporator saturation temperature dropped below 0°C. Table 9 shows that system capacity and compressor work decreased with increasing R-13B1 concentration using both the generic and TXV approach. COPc also was found to decrease with increasing R-13B1 concentration for both the generic and TXV approach.

### 2. Large System: R-11 Base Refrigerant

Two nonazeotropic refrigerant pairs have been modeled, the pairs R-11/R12 and R-11/R-22. Tables 10 and 11 show the modeling results for these pairs.

As Tables 10 and 11 show, mixing either R-12 or R-22 in an R-11 system results in a dramatic increase in the compressor power requirement of the system. This same result is seen when modeling with either the TXV or generic approach. This additional power requirement will cause motor failure or will cause the thermal overload control of the unit to shut the compressor off. Thus neither R-12 or R-22 are suitable replacement refrigerants for the R-11 system due to the compressor power overload.

TABLE 8. MODELING RESULTS FOR R-22/R-11 MIXTURE

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 100.0 | 100.0 | High Pres (kPa) | 1933.3 | 1933.3 |
| | | Low Pres. (kPa) | 527.1 | 527.1 |
| | | Superheat (C) | 5.0 | 5.0 |
| | | Flow Rate (kg/s) | 0.2965 | 0.2965 |
| | | COPc | 4.0 | 4.0 |
| | | Compressor Work (W) | 12500. | 12500. |
| | | Q Evap (W) | 49823. | 49823. |
| | | % Capacity Change | --- | --- |
| 90.0 | 93.5 | High Pres (kPa) | 1812.2 | 1812.2 |
| | | Low Pres. (kPa) | 527.1 | 369.2 |
| | | Superheat (C) | - 5.8* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.1979 |
| | | COPc | ---- | 3.2 |
| | | Compressor Work (W) | ---- | 10454. |
| | | Q Evap (W) | ---- | 33178. |
| | | % Capacity Change | ---- | - 33.4 |
| 80.0 | 86.4 | High Pres (kPa) | 1690.3 | 1690.3 |
| | | Low Pres. (kPa) | 527.1 | 243.8 |
| | | Superheat (C) | - 16.4* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.1300 |
| | | COPc | ---- | 2.6 |
| | | Compressor Work (W) | ---- | 8297. |
| | | Q Evap (W) | ---- | 21699. |
| | | % Capacity Change | ---- | - 56.5 |
| 70.0 | 78.8 | High Pres (kPa) | 1565.5 | 1565.5 |
| | | Low Pres. (kPa) | 527.1 | 175.4 |
| | | Superheat (C) | - 25.5* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.0924 |
| | | COPc | ---- | 2.3 |
| | | Compressor Work (W) | ---- | 6566. |
| | | Q Evap (W) | ---- | 15302. |
| | | % Capacity Change | ---- | - 69.3 |
| 60.0 | 70.4 | High Pres (kPa) | 1435.2 | 1435.2 |
| | | Low Pres. (kPa) | 527.1 | 133.5 |
| | | Superheat (C) | - 33.6* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.0698 |
| | | COPc | ---- | 2.2 |
| | | Compressor Work (W) | ---- | 5238. |
| | | Q Evap (W) | ---- | 11476. |
| | | % Capacity Change | ---- | - 77.0 |
| 50.0 | 61.4 | High Pres (kPa) | 1295.8 | 1295.8 |
| | | Low Pres. (kPa) | 527.1 | 105.6 |
| | | Superheat (C) | - 40.9* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.0550 |
| | | COPc | ---- | 2.1 |

TABLE 8. MODELING RESULTS FOR R-22/R-11 MIXTURE (concluded).

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 50.0 (continued) | 61.4 | Compressor Work (W) | ---- | 4201. |
| | | Q Evap (W) | ---- | 8981. |
| | | % Capacity Change | ---- | - 82.0 |
| 40.0 | 51.4 | High Pres (kPa) | 1142.6 | 1142.6 |
| | | Low Pres. (kPa) | 527.1* | 85.9 |
| | | Superheat (C) | - 47.8* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.0446 |
| | | COPc | ---- | 2.2 |
| | | Compressor Work (W) | ---- | 3366. |
| | | Q Evap (W) | ---- | 7244. |
| | | % Capacity Change | ---- | - 85.5 |
| 30.0 | 40.5 | High Pres (kPa) | 969.4 | 969.4 |
| | | Low Pres. (kPa) | 527.1* | 71.2 |
| | | Superheat (C) | - 54.4* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.0369 |
| | | COPc | ---- | 2.2 |
| | | Compressor Work (W) | ---- | 2672. |
| | | Q Evap (W) | ---- | 5973. |
| | | % Capacity Change | ---- | - 88.0 |
| 20.0 | 28.4 | High Pres (kPa) | 768.0 | 768.0 |
| | | Low Pres. (kPa) | 527.1* | 59.8 |
| | | Superheat (C) | - 60.8* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.0309 |
| | | COPc | ---- | 2.4 |
| | | Compressor Work (W) | ---- | 2069. |
| | | Q Evap (W) | ---- | 5008. |
| | | % Capacity Change | ---- | - 90.0 |
| 10.0 | 15.0 | High Pres (kPa) | 527.6 | 527.6 |
| | | Low Pres. (kPa) | 527.1* | 50.8 |
| | | Superheat (C) | - 67.2* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.0262 |
| | | COPc | ---- | 2.8 |
| | | Compressor Work (W) | ---- | 1506. |
| | | Q Evap (W) | ---- | 4254. |
| | | % Capacity Change | ---- | - 91.5 |
| 0.0 | 0.0 | High Pres (kPa) | 243.3 | 243.3 |
| | | Low Pres. (kPa) | 527.1* | 43.5 |
| | | Superheat (C) | - 73.6* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.0224 |
| | | COPc | ---- | 4.3 |
| | | Compressor Work (W) | ---- | 849. |
| | | Q Evap (W) | ---- | 3649. |
| | | % Capacity Change | ---- | - 92.7 |

* Compressor will fail due to slugging

**TABLE 9. MODELING RESULTS FOR R-22/R-13B1 MIXTURE**

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 100.0 | 100.0 | High Pres (kPa) | 1933.3 | 1933.3 |
| | | Low Pres. (kPa) | 527.1 | 527.1 |
| | | Superheat (C) | 5.0 | 5.0 |
| | | Flow Rate (kg/s) | 0.2965 | 0.2965 |
| | | COPc | 4.0 | 4.0 |
| | | Compressor Work (W) | 12500. | 12500. |
| | | Q Evap (W) | 49823. | 49823. |
| | | % Capacity Change | --- | --- |
| 90.0 | 93.9 | High Pres (kPa) | 2018.4 | 2018.4 |
| | | Low Pres. (kPa) | 527.1 | 547.0 |
| | | Superheat (C) | 6.2 | 5.0 |
| | | Flow Rate (kg/s) | 0.2963 | 0.3089 |
| | | COPc | 3.8 | 3.9 |
| | | Compressor Work (W) | 12376. | 12454. |
| | | Q Evap (W) | 46646. | 48524. |
| | | % Capacity Change | - 6.38 | - 2.61 |
| 80.0 | 87.3 | High Pres (kPa) | 2104.0 | 2104.0 |
| | | Low Pres. (kPa) | 527.1 | 569.9 |
| | | Superheat (C) | 7.4** | 5.0 |
| | | Flow Rate (kg/s) | 0.2961 | 0.3234 |
| | | COPc | 3.6 | 3.8 |
| | | Compressor Work (W) | 12199. | 12373. |
| | | Q Evap (W) | 43526. | 47302. |
| | | % Capacity Change | - 12.6 | - 5.06 |
| 70.0 | 80.1 | High Pres (kPa) | 2190.0 | 2190.0 |
| | | Low Pres. (kPa) | 527.1 | 596.4 |
| | | Superheat (C) | 8.9** | 5.0 |
| | | Flow Rate (kg/s) | 0.2959 | 0.3402 |
| | | COPc | 3.4 | 3.8 |
| | | Compressor Work (W) | 11973. | 12258. |
| | | Q Evap (W) | 40470. | 46162. |
| | | % Capacity Change | - 18.8 | - 7.35 |
| 60.0 | 72.1 | High Pres (kPa) | 2276.4 | 2276.4 |
| | | Low Pres. (kPa) | 527.1 | 627.2 |
| | | Superheat (C) | 10.5** | 5.0 |
| | | Flow Rate (kg/s) | 0.2957 | 0.3601 |
| | | COPc | 3.2 | 3.7 |
| | | Compressor Work (W) | 11701. | 12107. |
| | | Q Evap (W) | 37484. | 45105. |
| | | % Capacity Change | - 24.8 | - 9.47 |
| 50.0 | 63.3 | High Pres (kPa) | 2363.3 | 2363.3 |
| | | Low Pres. (kPa) | 527.1 | 662.8 |
| | | Superheat (C) | 12.2** | 5.0 |
| | | Flow Rate (kg/s) | 0.2955 | 0.3835 |
| | | COPc | 3.0 | 3.7 |

**TABLE 9. MODELING RESULTS FOR R-22/R-13B1 MIXTURE** (Concluded).

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 50.0 (continued) | 63.3 | Compressor Work (W) | 11382. | 11920. |
| | | Q Evap (W) | 34575. | 44118. |
| | | % Capacity Change | - 30.6 | - 11.5 |
| 40.0 | 53.4 | High Pres (kPa) | 2450.3 | 2450.3 |
| | | Low Pres. (kPa) | 527.1** | 703.4 |
| | | Superheat (C) | 14.2** | 5.0 |
| | | Flow Rate (kg/s) | 0.2954 | 0.4107 |
| | | COPc | 2.9 | 3.7 |
| | | Compressor Work (W) | 11020. | 11689. |
| | | Q Evap (W) | 31753. | 43163. |
| | | % Capacity Change | - 36.3 | - 13.4 |
| 30.0 | 42.5 | High Pres (kPa) | 2536.7 | 2536.7 |
| | | Low Pres. (kPa) | 527.1** | 748.6 |
| | | Superheat (C) | 16.3** | 5.0 |
| | | Flow Rate (kg/s) | 0.2952 | 0.4416 |
| | | COPc | 2.7 | 3.7 |
| | | Compressor Work (W) | 10615. | 11407. |
| | | Q Evap (W) | 29029. | 42157. |
| | | % Capacity Change | - 41.7 | - 15.4 |
| 20.0 | 30.1 | High Pres (kPa) | 2621.2 | 2621.2 |
| | | Low Pres. (kPa) | 527.1** | 796.3 |
| | | Superheat (C) | 18.4** | 5.0 |
| | | Flow Rate (kg/s) | 0.2951 | 0.4752 |
| | | COPc | 2.6 | 3.7 |
| | | Compressor Work (W) | 10166. | 11064. |
| | | Q Evap (W) | 26417. | 40959. |
| | | % Capacity Change | - 47.0 | - 17.8 |
| 10.0 | 16.1 | High Pres (kPa) | 2700.8 | 2700.8 |
| | | Low Pres. (kPa) | 527.1** | 842.6 |
| | | Superheat (C) | 20.5** | 5.0 |
| | | Flow Rate (kg/s) | 0.2951 | 0.5089 |
| | | COPc | 2.5 | 3.7 |
| | | Compressor Work (W) | 9668. | 10644. |
| | | Q Evap (W) | 23934. | 39390. |
| | | % Capacity Change | - 52.0 | - 20.9 |
| 0.0 | 0.0 | High Pres (kPa) | 2769.9 | 2769.9 |
| | | Low Pres. (kPa) | 527.1** | 882.2 |
| | | Superheat (C) | 22.2** | 5.0 |
| | | Flow Rate (kg/s) | 0.2952 | 0.5388 |
| | | COPc | 2.4 | 3.7 |
| | | Compressor Work (W) | 9117. | 10131. |
| | | Q Evap (W) | 21599. | 37300. |
| | | % Capacity Change | - 56.7 | - 25.1 |

** Potential freezing in water chiller

## TABLE 10. MODELING RESULTS FOR R-11/R-12 MIXTURE

| MASS % R-11 | MOL % R-11 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 100.0 | 100.0 | High Pres (kPa) | 243.3 | 243.3 |
| | | Low Pres. (kPa) | 43.5 | 43.5 |
| | | Superheat (C) | 5.0 | 5.0 |
| | | Flow Rate (kg/s) | 2.6426 | 2.6426 |
| | | COPc | 4.3 | 4.3 |
| | | Compressor Work (W) | 100000. | 100000. |
| | | Q Evap (W) | 429779. | 429779. |
| 90.0 | 88.8 | High Pres (kPa) | 340.7 | 340.7 |
| | | Low Pres. (kPa) | 43.5** | 48.3 |
| | | Superheat (C) | 7.5 | 5.0 |
| | | Flow Rate (kg/s) | 2.6399 | 2.9393 |
| | | COPc | 3.3 | 3.5 |
| | | Compressor Work (W) | 126047.# | 132080.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 80.0 | 77.9 | High Pres (kPa) | 443.3 | 443.3 |
| | | Low Pres. (kPa) | 43.5** | 54.2 |
| | | Superheat (C) | 10.1 | 5.0 |
| | | Flow Rate (kg/s) | 2.6373 | 3.2998 |
| | | COPc | 2.8 | 3.1 |
| | | Compressor Work (W) | 145906.# | 162426.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 70.0 | 67.3 | High Pres (kPa) | 542.5 | 542.5 |
| | | Low Pres. (kPa) | 43.5** | 61.4 |
| | | Superheat (C) | 13.0 | 5.0 |
| | | Flow Rate (kg/s) | 2.6350 | 3.7467 |
| | | COPc | 2.5 | 2.9 |
| | | Compressor Work (W) | 162401.# | 193863.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 60.0 | 56.9 | High Pres (kPa) | 639.2 | 639.2 |
| | | Low Pres. (kPa) | 43.5** | 70.6 |
| | | Superheat (C) | 16.1 | 5.0 |
| | | Flow Rate (kg/s) | 2.6327 | 4.3150 |
| | | COPc | 2.2 | 2.8 |
| | | Compressor Work (W) | 176827.# | 228323.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 50.0 | 46.8 | High Pres (kPa) | 734.0 | 734.0 |
| | | Low Pres. (kPa) | 43.5** | 82.6 |
| | | Superheat (C) | 19.6 | 5.0 |
| | | Flow Rate (kg/s) | 2.6306 | 5.0611 |
| | | COPc | 2.0 | 2.7 |
| | | Compressor Work (W) | 189693.# | 267700.# |

TABLE 10. MODELING RESULTS FOR R-11/R-12 MIXTURE (Concluded).

| MASS % R-11 | MOL % R-11 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 50.0 (continued) | 46.8 | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 40.0 | 37.0 | High Pres (kPa) | 827.6 | 827.6 |
| | | Low Pres. (kPa) | 43.5** | 98.9 |
| | | Superheat (C) | 23.6** | 5.0 |
| | | Flow Rate (kg/s) | 2.6286 | 6.0817 |
| | | COPc | 1.8# | 2.7# |
| | | Compressor Work (W) | 202032.# | 314307.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 30.0 | 27.4 | High Pres (kPa) | 920.9 | 920.9 |
| | | Low Pres. (kPa) | 43.5** | 122.2 |
| | | Superheat (C) | 28.3** | 5.0 |
| | | Flow Rate (kg/s) | 2.6268 | 7.5564 |
| | | COPc | 1.7# | 2.8# |
| | | Compressor Work (W) | 213532.# | 371269.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 20.0 | 18.0 | High Pres (kPa) | 1014.7 | 1014.7 |
| | | Low Pres. (kPa) | 43.5** | 157.9 |
| | | Superheat (C) | 34.0** | 5.0 |
| | | Flow Rate (kg/s) | 2.6250 | 9.8514 |
| | | COPc | 1.6# | 2.9# |
| | | Compressor Work (W) | 224602.# | 442819.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 10.0 | 8.9 | High Pres (kPa) | 1109.9 | 1109.9 |
| | | Low Pres. (kPa) | 43.5** | 217.9 |
| | | Superheat (C) | 41.9** | 5.0 |
| | | Flow Rate (kg/s) | 2.6233 | 13.7975 |
| | | COPc | 1.4# | 3.3# |
| | | Compressor Work (W) | 235420.# | 533235.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 0.0 | 0.0 | High Pres (kPa) | 1207.9 | 1207.9 |
| | | Low Pres. (kPa) | 43.5** | 327.4 |
| | | Superheat (C) | 54.8** | 5.0 |
| | | Flow Rate (kg/s) | 2.6218 | 21.3358 |
| | | COPc | 1.3# | 4.1# |
| | | Compressor Work (W) | 246096.# | 637029.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |

** Potential freezing in water chiller
# Compressor will fail due to power overload

## TABLE 11. MODELING RESULTS FOR R-11/R-22 MIXTURE

| MASS % R-11 | MOL % R-11 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 100.0 | 100.0 | High Pres (kPa) | 234.3 | 234.3 |
| | | Low Pres. (kPa) | 43.5 | 43.5 |
| | | Superheat (C) | 5.0 | 5.0 |
| | | Flow Rate (kg/s) | 2.6426 | 2.6426 |
| | | COPc | 4.3 | 4.3 |
| | | Compressor Work (W) | 100000. | 100000. |
| | | Q Evap (W) | 429779. | 429779. |
| 90.0 | 85.0 | High Pres (kPa) | 527.6 | 527.6 |
| | | Low Pres. (kPa) | 43.5 | 50.8 |
| | | Superheat (C) | 8.6** | 5.0 |
| | | Flow Rate (kg/s) | 2.6370 | 3.0907 |
| | | COPc | 2.6 | 2.8 |
| | | Compressor Work (W) | 163446.# | 177361.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 80.0 | 71.6 | High Pres (kPa) | 768.0 | 768.0 |
| | | Low Pres. (kPa) | 43.5 | 59.8 |
| | | Superheat (C) | 12.4** | 5.0 |
| | | Flow Rate (kg/s) | 2.6324 | 3.6430 |
| | | COPc | 2.1 | 2.4 |
| | | Compressor Work (W) | 203488.# | 243075.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 70.0 | 59.5 | High Pres (kPa) | 969.4 | 969.4 |
| | | Low Pres. (kPa) | 43.5 | 71.2 |
| | | Superheat (C) | 16.2** | 5.0 |
| | | Flow Rate (kg/s) | 2.6286 | 4.3402 |
| | | COPc | 1.8 | 2.2 |
| | | Compressor Work (W) | 236271.# | 314609.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 60.0 | 48.6 | High Pres (kPa) | 1142.6 | 1142.6 |
| | | Low Pres. (kPa) | 43.5 | 85.9 |
| | | Superheat (C) | 20.2** | 5.0 |
| | | Flow Rate (kg/s) | 2.6254 | 5.2473 |
| | | COPc | 1.6 | 2.2 |
| | | Compressor Work (W) | 265815.# | 396359.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 50.0 | 38.6 | High Pres (kPa) | 1295.8 | 1295.8 |
| | | Low Pres. (kPa) | 43.5 | 105.6 |
| | | Superheat (C) | 24.6** | 5.0 |
| | | Flow Rate (kg/s) | 2.6277 | 6.4737 |
| | | COPc | 1.5 | 2.1 |
| | | Compressor Work (W) | 293739.# | 494684.# |

TABLE 11. MODELING RESULTS FOR R-11/R-22 MIXTURE (Concluded)

| MASS % R-11 | MOL % R-11 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 50.0 (continued) | 48.6 | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 40.0 | 29.6 | High Pres (kPa) | 1435.2 | 1435.2 |
| | | Low Pres. (kPa) | 43.5** | 133.5 |
| | | Superheat (C) | 29.4 | 5.0 |
| | | Flow Rate (kg/s) | 2.6204 | 8.2186 |
| | | COPc | 1.4 | 2.2 |
| | | Compressor Work (W) | 320896.# | 616873.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 30.0 | 21.2 | High Pres (kPa) | 1565.5 | 1565.5 |
| | | Low Pres. (kPa) | 43.5** | 175.4 |
| | | Superheat (C) | 34.9 | 5.0 |
| | | Flow Rate (kg/s) | 2.6184 | 10.8776 |
| | | COPc | 1.3 | 2.3 |
| | | Compressor Work (W) | 347733.# | 773217.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 20.0 | 13.6 | High Pres (kPa) | 1690.3 | 1690.3 |
| | | Low Pres. (kPa) | 43.5** | 243.8 |
| | | Superheat (C) | 41.7 | 5.0 |
| | | Flow Rate (kg/s) | 2.6167 | 15.3145 |
| | | COPc | 1.2 | 2.6 |
| | | Compressor Work (W) | 374574.# | 977049.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 10.0 | 6.5 | High Pres (kPa) | 1812.2 | 1812.2 |
| | | Low Pres. (kPa) | 43.5** | 362.9 |
| | | Superheat (C) | 51.1 | 5.0 |
| | | Flow Rate (kg/s) | 2.6152 | 23.3096 |
| | | COPc | 1.1 | 3.2 |
| | | Compressor Work (W) | 401626.# | 1231072.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |
| 0.0 | 0.0 | High Pres (kPa) | 1933.3 | 1933.3 |
| | | Low Pres. (kPa) | 43.5** | 527.1 |
| | | Superheat (C) | 64.4 | 5.0 |
| | | Flow Rate (kg/s) | 2.6140 | 34.9224 |
| | | COPc | 1.1 | 4.0 |
| | | Compressor Work (W) | 429036.# | 1472058.# |
| | | Q Evap (W) | ---- | ---- |
| | | % Capacity Change | ---- | ---- |

** Potential freezing in water chiller
# Compressor will fail due to power overload

**TASK V: RECOMMEND FUTURE WORK**

Based on the results obtained to date on this contract, Mainstream has identified several preliminary tasks to be done in Phase II of this effort.

1. Set up a heat pump test stand apparatus to determine actual performance using the selected refrigerant mixtures in the base system. The objective of this task will be to verify the Phase I modeling and to perform some long-term system testing. This task would investigate how temperatures and heat transfer rates are affected when a refrigerant is substituted in a TXV-controlled system. These tests would also verify any potential compressor slugging, power overload, or water chiller problems.

2. Verify vapor-liquid equilibrium data of refrigerant mixtures. The goal of this task will be to verify the thermodynamic properties generated by the CSD equation of state. This will be accomplished by experimentally generating dew and bubble points.

3. Periodically check system hardware (valves, seals, lines, etc.) for any adverse affects caused by refrigerant/lubricant. This will ensure that the refrigerant mixture and lubricant do not adversely affect system components.

4. Perform lubrication tests and consult with refrigeration experts to determine which lubricant is best for a particular mixture. This may be an easy problem because many refrigerant lubricants are used for more than one refrigerant. Mainstream plans to consult with refrigerant manufacturers for recommendations.

5. Perform experiments to identify suitable replacement refrigerants for the R-11 baseline system. Suitable candidates would be refrigerants with volatilities similar to R-11. Halon-1211 and R-114B2 are the most likely candidates, with volatilities approaching R-11.

6. Study development of system hardware suitable for use with refrigerant mixtures. Components such as compressors and expansion devices should be studied to see what modifications or changes can be made with these components to fully utilize the advantages of refrigerant mixtures.

## SECTION IV

## CONCLUSIONS

1. The effect of the expansion device plays an important role in the changing system performance when substituting refrigerants in an air-conditioning system. If the refrigerant is changed in a system equipped with a TXV, significant changes in evaporator conditions and system performance result. This is because the pressure/temperature saturation properties of the fluid in the TXV are used to control the evaporator pressure. If the fluid in the cycle changes, the pressure/temperature relationship of the cycle fluid changes. Thus, the evaporator saturation temperature corresponding to the TXV pressure has changed. This type of behavior is not seen when modeling the system using a generic expansion device, which allows the pressure to change to match the desired evaporator saturation temperature.

2. Refrigerant R-502 was found to be the best substitute for the R-22 baseline system. The R-22/R-502 mixture gives a slight decrease in system capacity over the entire concentration range. No adverse affects to the compressor or water chiller were found for the R-22/R-502 mixture.

3. Refrigerant R-13B1 is a suitable substitute for the R-22 baseline system but its use results in a decrease in system capacity. The potential for freezing in the water chiller exists for this mixture at R-13B1 concentrations above 20 wt%. This problem could be overcome by utilizing a material that lowers the freezing point of the water in the chiller.

4. Refrigerant R-12 is a suitable substitute for the R-22 baseline system if the R-12 concentration can be maintained below 60 wt%. System capacity decreases with increasing R-12 concentration until a concentration of 60 wt% is reached. An R-12 concentration of 60 wt% or above will result in failure of the compressor due to liquid slugging.

5. Refrigerant R-290 is not a suitable substitute for the R-22 system. Its use results in an increase in the compressor power for the system over the entire concentration range. This additional power requirement will cause motor failure or will cause the thermal overload control of the unit to shut the compressor off.

6. Refrigerant R-11 is not a suitable substitute for the R-22 baseline system. Its use will result in compressor failure due to liquid slugging over the entire R-22/R-11 concentration range.

7. Refrigerants R-12 and R-22 are not suitable substitutes for the R-11 baseline system. Use of either of these refrigerants results in an increase in the compressor power of the system. This additional power requirement will cause motor failure or will cause the unit's thermal overload control to shut the compressor off.

8. Replacement of the system lubricant should not be necessary unless a system leak occurs in the compressor crankcase or oil separator. However, if a system leak results in compressor failure, the compressor and oil should be checked thoroughly and tested.

9. None of the refrigerant mixtures considered should posses flammability with the exception of R-22/R-290, which may be flammable in high R-290 concentrations. Mainstream was unable to find any literature to clarify this point.

# SECTION V

# REFERENCES

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# APPENDIX A

## TABLES OF THERMODYNAMIC PROPERTY DATA FOR REFRIGERANT MIXTURES

## A. INTRODUCTION

The data contained in Appendix A was generated through the use of FORTRAN subroutines and functions implementing the CSD equation of state. These routines were supplied to Mainstream by Dr. Mark McLinden of the National Bureau of Standards. The routines were intended to supply property information to a user's application program, such as the heat pump simulator developed by Mainstream. Included in these routines were two subroutines to generate the tablular data contained in Appendix A.

## B. NOMENCLATURE

The following nomenclature is used in the Tables of Appendix A.

xl = liquid mol fraction of component A
xv = vapor mol fraction of component A
p = pressure
vl = liquid specific volume
vv = vapor specific volume
hl = liquid enthalpy
hv = vapor enthalpy
sl = liquid entropy
sv = vapor entropy
cvl = liquid isochoric heat capacity
cvv = vapor isochoric heat capacity
cpl = liquid isobaric heat capacity
cpv = vapor isobaric heat capacity
cv = vapor isochoric heat capacity
cp = vapor isobaric heat capacity
vsnd = sonic speed

## TABLE A.1 - SATURATED VAPOR-LIQUID PROPERTIES FOR R-11/R-12 MIXTURE

DEW/BUBBLE LINES AT T = 273.1 K
COMPONENT A: R12     COMPONENT B: R11
MIXING COEFFICIENT, F = .0050

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL | FRAC A) | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- | | (KJ/KG MOL K) | | ---------------- | |
| .0000 | .0000 | 40.21 | .08959 | 55.453 | 4609.1 | 30641.8 | 18.221 | 113.527 | 106.893 | 66.773 | 117.936 | 75.670 |
| .1000 | .4678 | 69.03 | .08908 | 32.082 | 4620.9 | 27150.7 | 20.843 | 109.662 | 106.359 | 64.164 | 117.393 | 73.324 |
| .2000 | .6572 | 96.91 | .08860 | 22.692 | 4626.0 | 25708.0 | 22.218 | 104.295 | 105.801 | 63.142 | 116.867 | 72.576 |
| .3000 | .7609 | 124.00 | .08816 | 17.610 | 4624.5 | 24896.4 | 23.052 | 100.245 | 105.218 | 62.609 | 116.361 | 72.321 |
| .4000 | .8273 | 150.47 | .08776 | 14.412 | 4616.2 | 24360.5 | 23.483 | 97.061 | 104.608 | 62.289 | 115.880 | 72.286 |
| .5000 | .8740 | 176.49 | .08741 | 12.201 | 4601.2 | 23968.7 | 23.565 | 94.436 | 103.970 | 62.080 | 115.430 | 72.368 |
| .6000 | .9094 | 202.27 | .08711 | 10.572 | 4579.4 | 23660.8 | 23.314 | 92.182 | 103.300 | 61.936 | 115.020 | 72.525 |
| .7000 | .9376 | 228.04 | .08687 | 9.310 | 4550.8 | 23405.0 | 22.716 | 90.175 | 102.598 | 61.853 | 114.658 | 72.737 |
| .8000 | .9612 | 254.08 | .08670 | 8.295 | 4515.6 | 23182.6 | 21.720 | 88.322 | 101.859 | 61.759 | 114.359 | 72.992 |
| .9000 | .9816 | 280.69 | .08661 | 7.451 | 4474.0 | 22981.7 | 20.192 | 86.543 | 101.081 | 61.705 | 114.139 | 73.290 |
| 1.0000 | 1.0000 | 308.25 | .08662 | 6.731 | 4426.4 | 22793.8 | 17.427 | 84.670 | 100.259 | 61.665 | 114.023 | 73.632 |

DEW/BUBBLE LINES AT T = 283.1 K
COMPONENT A: R12     COMPONENT B: R11
MIXING COEFFICIENT, F = .0050

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL | FRAC A) | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- | | (KJ/KG MOL K) | | ---------------- | |
| .0000 | .0000 | 60.63 | .09093 | 37.859 | 5796.4 | 31346.5 | 22.484 | 112.719 | 108.024 | 68.059 | 119.308 | 77.200 |
| .1000 | .4381 | 98.87 | .09045 | 23.030 | 5803.3 | 28037.4 | 25.085 | 109.437 | 107.479 | 65.656 | 118.783 | 75.126 |
| .2000 | .6297 | 136.04 | .09001 | 16.598 | 5803.7 | 26555.0 | 26.440 | 104.328 | 106.909 | 64.649 | 118.279 | 74.465 |
| .3000 | .7384 | 172.32 | .08961 | 12.993 | 5797.6 | 25687.5 | 27.254 | 100.327 | 106.311 | 64.112 | 117.802 | 74.286 |
| .4000 | .8094 | 207.91 | .08926 | 10.677 | 5785.0 | 25100.0 | 27.667 | 97.114 | 105.684 | 63.787 | 117.356 | 74.332 |
| .5000 | .8602 | 243.04 | .08897 | 9.056 | 5766.0 | 24662.3 | 27.732 | 94.426 | 105.025 | 63.578 | 116.951 | 74.508 |
| .6000 | .8990 | 277.96 | .08874 | 7.849 | 5740.5 | 24313.1 | 27.465 | 92.091 | 104.332 | 63.437 | 116.596 | 74.771 |
| .7000 | .9302 | 312.99 | .08859 | 6.909 | 5708.8 | 24019.2 | 26.853 | 89.992 | 103.602 | 63.341 | 116.306 | 75.101 |
| .8000 | .9565 | 348.49 | .08851 | 6.148 | 5671.1 | 23760.7 | 25.845 | 88.037 | 102.830 | 63.275 | 116.100 | 75.490 |
| .9000 | .9793 | 384.86 | .08855 | 5.513 | 5627.9 | 23524.7 | 24.308 | 86.143 | 102.014 | 63.232 | 116.002 | 75.940 |
| 1.0000 | 1.0000 | 422.63 | .08870 | 4.970 | 5579.6 | 23301.7 | 21.538 | 84.127 | 101.146 | 63.207 | 116.048 | 76.455 |

## TABLE A.1 - SATURATED VAPOR-LIQUID PROPERTIES FOR R-11/R-12 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 293.1 K
COMPONENT A: R12 COMPONENT B: R11
MIXING COEFFICIENT, F = .0050

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 88.54 | .09234 | 26.614 | 6997.8 | 32047.9 | 26.644 | 112.096 | 109.080 | 69.312 | 120.684 | 78.768 |
| .1000 | .4105 | 138.05 | .09190 | 16.911 | 7000.0 | 28907.4 | 29.226 | 109.308 | 108.524 | 67.107 | 120.182 | 76.969 |
| .2000 | .6029 | 186.41 | .09150 | 12.401 | 6995.9 | 27393.9 | 30.562 | 104.455 | 107.940 | 66.128 | 119.707 | 76.422 |
| .3000 | .7159 | 233.82 | .09115 | 9.788 | 6985.7 | 26473.7 | 31.358 | 100.512 | 107.326 | 65.595 | 119.264 | 76.344 |
| .4000 | .7913 | 280.52 | .09086 | 8.075 | 6969.2 | 25834.5 | 31.754 | 97.277 | 106.679 | 65.274 | 118.863 | 76.502 |
| .5000 | .8460 | 326.81 | .09063 | 6.860 | 6946.6 | 25349.3 | 31.804 | 94.528 | 105.998 | 65.071 | 118.514 | 76.803 |
| .6000 | .8882 | 373.01 | .09048 | 5.946 | 6918.1 | 24956.0 | 31.522 | 92.111 | 105.279 | 64.939 | 118.232 | 77.207 |
| .7000 | .9224 | 419.52 | .09043 | 5.229 | 6884.0 | 24620.5 | 30.898 | 89.916 | 104.518 | 64.855 | 118.036 | 77.698 |
| .8000 | .9514 | 466.80 | .09048 | 4.646 | 6844.8 | 24321.8 | 29.882 | 87.852 | 103.710 | 64.805 | 117.953 | 78.271 |
| .9000 | .9769 | 515.41 | .09066 | 4.158 | 6801.1 | 24045.9 | 28.339 | 85.833 | 102.849 | 64.780 | 118.021 | 78.933 |
| 1.0000 | 1.0000 | 566.06 | .09100 | 3.737 | 6753.8 | 23782.3 | 25.568 | 83.656 | 101.928 | 64.776 | 118.293 | 79.698 |

DEW/BUBBLE LINES AT T = 303.1 K
COMPONENT A: R12 COMPONENT B: R11
MIXING COEFFICIENT, F = .0050

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 125.67 | .09382 | 19.192 | 8213.3 | 32743.1 | 30.710 | 111.626 | 110.060 | 70.535 | 122.074 | 80.394 |
| .1000 | .3848 | 188.41 | .09342 | 12.666 | 8211.2 | 29758.4 | 33.273 | 109.258 | 109.491 | 68.521 | 121.600 | 78.875 |
| .2000 | .5770 | 249.96 | .09307 | 9.439 | 8203.1 | 28221.1 | 34.591 | 104.653 | 108.892 | 67.582 | 121.159 | 78.471 |
| .3000 | .6935 | 310.59 | .09278 | 7.508 | 8189.0 | 27251.4 | 35.371 | 100.776 | 108.260 | 67.064 | 120.761 | 78.525 |
| .4000 | .7729 | 370.58 | .09255 | 6.217 | 8169.0 | 26560.9 | 35.751 | 97.524 | 107.593 | 66.755 | 120.417 | 78.826 |
| .5000 | .8312 | 430.29 | .09241 | 5.288 | 8143.5 | 26026.5 | 35.787 | 94.717 | 106.888 | 66.565 | 120.141 | 79.291 |
| .6000 | .8768 | 490.13 | .09236 | 4.584 | 8112.8 | 25586.4 | 35.494 | 92.218 | 106.140 | 66.450 | 119.954 | 79.883 |
| .7000 | .9142 | 550.59 | .09242 | 4.026 | 8077.2 | 25205.7 | 34.860 | 89.922 | 105.343 | 66.385 | 119.883 | 80.592 |
| .8000 | .9460 | 612.30 | .09262 | 3.570 | 8037.6 | 24862.4 | 33.838 | 87.741 | 104.493 | 66.358 | 119.967 | 81.419 |
| .9000 | .9742 | 676.00 | .09298 | 3.186 | 7995.0 | 24541.2 | 32.294 | 85.585 | 103.581 | 66.360 | 120.264 | 82.381 |
| 1.0000 | 1.0000 | 742.64 | .09355 | 2.854 | 7950.8 | 24230.5 | 29.528 | 83.230 | 102.598 | 66.387 | 120.858 | 83.510 |

## TABLE A.1 - SATURATED VAPOR-LIQUID PROPERTIES FOR R-11/R-12 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 313.1 K
COMPONENT A: R12 COMPONENT B: R11
MIXING COEFFICIENT, F = .0050

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 173.93 | .09540 | 14.152 | 9443.3 | 33429.0 | 34.687 | 111.282 | 110.961 | 71.732 | 123.488 | 82.100 |
| .1000 | .3610 | 251.91 | .09504 | 9.655 | 9437.1 | 30587.9 | 37.232 | 109.269 | 110.378 | 69.903 | 123.049 | 80.870 |
| .2000 | .5518 | 328.77 | .09474 | 7.302 | 9425.3 | 29033.3 | 38.533 | 104.903 | 109.763 | 69.015 | 122.653 | 80.640 |
| .3000 | .6712 | 404.82 | .09451 | 5.850 | 9407.8 | 28017.4 | 39.298 | 101.098 | 109.113 | 68.522 | 122.312 | 80.861 |
| .4000 | .7542 | 480.42 | .09437 | 4.861 | 9385.0 | 27275.8 | 39.664 | 97.835 | 108.423 | 68.234 | 122.041 | 81.348 |
| .5000 | .8161 | 555.98 | .09432 | 4.140 | 9357.3 | 26690.8 | 39.688 | 94.973 | 107.690 | 68.066 | 121.860 | 82.026 |
| .6000 | .8650 | 632.03 | .09439 | 3.587 | 9325.1 | 26201.3 | 39.385 | 92.390 | 106.909 | 67.975 | 121.799 | 82.867 |
| .7000 | .9054 | 709.21 | .09460 | 3.146 | 9289.2 | 25771.5 | 38.746 | 89.989 | 106.074 | 67.939 | 121.896 | 83.869 |
| .8000 | .9402 | 788.31 | .09498 | 2.783 | 9250.7 | 25378.6 | 37.721 | 87.684 | 105.175 | 67.945 | 122.211 | 85.048 |
| .9000 | .9713 | 870.33 | .09557 | 2.475 | 9211.2 | 25006.1 | 36.181 | 85.377 | 104.204 | 67.985 | 122.832 | 86.440 |
| 1.0000 | 1.0000 | 956.56 | .09643 | 2.207 | 9173.0 | 24640.5 | 33.429 | 82.822 | 103.146 | 68.056 | 123.896 | 88.106 |

DEW/BUBBLE LINES AT T = 323.1 K
COMPONENT A: R12 COMPONENT B: R11
MIXING COEFFICIENT, F = .0050

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 235.36 | .09707 | 10.641 | 10687.9 | 34102.2 | 38.581 | 111.037 | 111.781 | 72.908 | 124.941 | 83.914 |
| .1000 | .3389 | 330.63 | .09676 | 7.473 | 10678.1 | 31393.8 | 41.109 | 109.325 | 111.184 | 71.259 | 124.546 | 82.986 |
| .2000 | .5275 | 424.98 | .09653 | 5.730 | 10663.0 | 29827.2 | 42.395 | 105.188 | 110.551 | 70.433 | 124.208 | 82.964 |
| .3000 | .6491 | 518.76 | .09638 | 4.622 | 10642.7 | 28768.1 | 43.145 | 101.458 | 109.880 | 69.976 | 123.941 | 83.396 |
| .4000 | .7352 | 612.39 | .09633 | 3.853 | 10617.8 | 27976.1 | 43.500 | 98.189 | 109.165 | 69.718 | 123.765 | 84.120 |
| .5000 | .8005 | 706.41 | .09640 | 3.284 | 10588.7 | 27339.2 | 43.513 | 95.274 | 108.402 | 69.581 | 123.711 | 85.075 |
| .6000 | .8527 | 801.45 | .09660 | 2.843 | 10556.1 | 26797.3 | 43.204 | 92.608 | 107.584 | 69.525 | 123.818 | 86.245 |
| .7000 | .8962 | 898.33 | .09699 | 2.489 | 10521.4 | 26314.5 | 42.562 | 90.098 | 106.704 | 69.528 | 124.147 | 87.646 |
| .8000 | .9340 | 998.09 | .09759 | 2.195 | 10486.0 | 25866.5 | 41.541 | 87.659 | 105.749 | 69.579 | 124.786 | 89.318 |
| .9000 | .9681 | 1102.07 | .09847 | 1.944 | 10452.3 | 25435.5 | 40.012 | 85.187 | 104.708 | 69.671 | 125.876 | 91.333 |
| 1.0000 | 1.0000 | 1212.06 | .09972 | 1.725 | 10423.9 | 25005.8 | 37.282 | 82.406 | 103.559 | 69.804 | 127.650 | 93.815 |

## TABLE A.1 - SATURATED VAPOR-LIQUID PROPERTIES FOR R-11/R-12 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 333.1 K
COMPONENT A: R12 COMPONENT B: R11
MIXING COEFFICIENT, F = .0050

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 312.12 | .09886 | 8.138 | 11947.7 | 34759.6 | 42.397 | 110.870 | 112.518 | 74.068 | 126.453 | 85.870 |
| .1000 | .3183 | 426.76 | .09862 | 5.864 | 11934.6 | 32173.6 | 44.910 | 109.413 | 111.905 | 72.595 | 126.116 | 85.262 |
| .2000 | .5040 | 540.81 | .09845 | 4.552 | 11916.7 | 30599.5 | 46.181 | 105.493 | 111.253 | 71.841 | 125.852 | 85.491 |
| .3000 | .6272 | 654.68 | .09839 | 3.695 | 11894.3 | 29500.3 | 46.919 | 101.842 | 110.559 | 71.431 | 125.681 | 86.184 |
| .4000 | .7161 | 768.88 | .09845 | 3.089 | 11868.0 | 28658.5 | 47.263 | 98.571 | 109.816 | 71.214 | 125.633 | 87.209 |
| .5000 | .7845 | 884.06 | .09866 | 2.635 | 11838.5 | 27968.3 | 47.269 | 95.606 | 109.019 | 71.119 | 125.748 | 88.524 |
| .6000 | .8398 | 1001.04 | .09904 | 2.279 | 11807.1 | 27371.3 | 46.957 | 92.855 | 108.159 | 71.109 | 126.086 | 90.134 |
| .7000 | .8865 | 1120.86 | .09964 | 1.990 | 11775.3 | 26830.9 | 46.316 | 90.232 | 107.227 | 71.164 | 126.737 | 92.083 |
| .8000 | .9274 | 1244.86 | .10052 | 1.749 | 11745.5 | 26321.9 | 45.304 | 87.649 | 106.207 | 71.275 | 127.842 | 94.455 |
| .9000 | .9647 | 1374.86 | .10178 | 1.541 | 11721.3 | 25824.0 | 43.796 | 84.994 | 105.081 | 71.438 | 129.634 | 97.398 |
| 1.0000 | 1.0000 | 1513.36 | .10353 | 1.358 | 11708.3 | 25318.3 | 41.103 | 81.955 | 103.821 | 71.656 | 132.525 | 101.165 |

DEW/BUBBLE LINES AT T = 343.1 K
COMPONENT A: R12 COMPONENT B: R11
MIXING COEFFICIENT, F = .0050

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 406.49 | .10079 | 6.317 | 13223.1 | 35397.8 | 46.141 | 110.762 | 113.169 | 75.218 | 128.051 | 88.009 |
| .1000 | .2991 | 542.57 | .10061 | 4.656 | 13207.3 | 32924.7 | 48.640 | 109.519 | 112.539 | 73.917 | 127.790 | 87.750 |
| .2000 | .4813 | 678.53 | .10054 | 3.656 | 13187.2 | 31347.0 | 49.898 | 105.804 | 111.866 | 73.246 | 127.623 | 88.279 |
| .3000 | .6054 | 814.87 | .10059 | 2.985 | 13163.5 | 30210.4 | 50.625 | 102.233 | 111.145 | 72.894 | 127.580 | 89.298 |
| .4000 | .6968 | 952.23 | .10078 | 2.502 | 13136.8 | 29319.4 | 50.961 | 98.966 | 110.371 | 72.729 | 127.702 | 90.708 |
| .5000 | .7681 | 1091.39 | .10115 | 2.135 | 13108.3 | 28574.8 | 50.963 | 95.953 | 109.536 | 72.689 | 128.048 | 92.494 |
| .6000 | .8264 | 1233.39 | .10174 | 1.844 | 13079.6 | 27919.5 | 50.651 | 93.116 | 108.628 | 72.738 | 128.707 | 94.696 |
| .7000 | .8761 | 1379.56 | .10261 | 1.606 | 13053.2 | 27316.8 | 50.018 | 90.374 | 107.634 | 72.861 | 129.820 | 97.408 |
| .8000 | .9202 | 1531.68 | .10385 | 1.405 | 13032.5 | 26739.6 | 49.024 | 87.636 | 106.536 | 73.050 | 131.615 | 100.801 |
| .9000 | .9609 | 1692.21 | .10560 | 1.231 | 13022.9 | 26164.7 | 47.548 | 84.778 | 105.307 | 73.308 | 134.498 | 105.170 |
| 1.0000 | 1.0000 | 1864.69 | .10806 | 1.075 | 13033.5 | 25567.8 | 44.912 | 81.439 | 103.907 | 73.645 | 139.249 | 111.064 |

## TABLE A.1 - SATURATED VAPOR-LIQUID PROPERTIES FOR R-11/R-12 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 353.1 K
COMPONENT A: R12     COMPONENT B: R11
MIXING COEFFICIENT, F = .0050

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 520.85 | .10287 | 4.967 | 14514.9 | 36013.2 | 49.818 | 110.694 | 113.731 | 76.366 | 129.772 | 90.388 |
| .1000 | .2812 | 680.39 | .10278 | 3.735 | 14497.0 | 33644.5 | 52.304 | 109.631 | 113.081 | 75.233 | 129.610 | 90.513 |
| .2000 | .4593 | 840.45 | .10281 | 2.964 | 14475.5 | 32066.1 | 53.551 | 106.108 | 112.384 | 74.655 | 129.574 | 91.404 |
| .3000 | .5839 | 1001.65 | .10299 | 2.433 | 14451.3 | 30894.7 | 54.270 | 102.619 | 111.635 | 74.373 | 129.703 | 92.833 |
| .4000 | .6772 | 1164.76 | .10334 | 2.044 | 14425.4 | 29955.1 | 54.601 | 99.358 | 110.825 | 74.274 | 130.057 | 94.739 |
| .5000 | .7511 | 1330.77 | .10391 | 1.744 | 14399.6 | 29154.8 | 54.602 | 96.299 | 109.945 | 74.301 | 130.724 | 97.148 |
| .6000 | .8123 | 1500.97 | .10476 | 1.504 | 14376.0 | 28438.1 | 54.295 | 93.376 | 108.981 | 74.425 | 131.842 | 100.160 |
| .7000 | .8651 | 1677.08 | .10598 | 1.305 | 14358.1 | 27767.6 | 53.677 | 90.510 | 107.916 | 74.635 | 133.633 | 103.961 |
| .8000 | .9124 | 1861.44 | .10770 | 1.136 | 14351.2 | 27113.9 | 52.711 | 87.603 | 106.723 | 74.928 | 136.491 | 108.886 |
| .9000 | .9566 | 2057.43 | .11011 | .987 | 14363.7 | 26449.1 | 51.286 | 84.514 | 105.365 | 75.313 | 141.158 | 115.552 |
| 1.0000 | 1.0000 | 2270.17 | .11358 | .853 | 14410.5 | 25740.4 | 48.738 | 80.820 | 103.779 | 75.817 | 149.245 | 125.226 |

DEW/BUBBLE LINES AT T = 363.1 K
COMPONENT A: R12     COMPONENT B: R11
MIXING COEFFICIENT, F = .0050

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 657.63 | .10514 | 3.950 | 15824.2 | 36602.1 | 53.434 | 110.650 | 114.199 | 77.514 | 131.665 | 93.079 |
| .1000 | .2644 | 842.58 | .10515 | 3.023 | 15804.7 | 34329.9 | 55.908 | 109.738 | 113.527 | 76.553 | 131.637 | 93.639 |
| .2000 | .4381 | 1028.89 | .10531 | 2.422 | 15782.7 | 32753.4 | 57.147 | 106.395 | 112.804 | 76.077 | 131.776 | 94.972 |
| .3000 | .5625 | 1217.29 | .10564 | 1.998 | 15759.3 | 31549.4 | 57.859 | 102.987 | 112.022 | 75.877 | 132.141 | 96.919 |
| .4000 | .6575 | 1408.73 | .10619 | 1.682 | 15735.9 | 30561.8 | 58.188 | 99.735 | 111.171 | 75.857 | 132.819 | 99.473 |
| .5000 | .7337 | 1604.44 | .10701 | 1.434 | 15714.8 | 29704.1 | 58.194 | 96.632 | 110.240 | 75.968 | 133.945 | 102.723 |
| .6000 | .7975 | 1806.05 | .10820 | 1.234 | 15699.3 | 28922.4 | 57.899 | 93.621 | 109.210 | 76.187 | 135.735 | 106.868 |
| .7000 | .8532 | 2015.77 | .10987 | 1.066 | 15694.3 | 28177.8 | 57.306 | 90.622 | 108.057 | 76.507 | 138.564 | 112.269 |
| .8000 | .9038 | 2236.71 | .11221 | .922 | 15708.0 | 27437.2 | 56.385 | 87.529 | 106.746 | 76.935 | 143.137 | 119.596 |
| .9000 | .9519 | 2473.54 | .11557 | .794 | 15753.9 | 26665.6 | 55.036 | 84.174 | 105.220 | 77.495 | 150.934 | 130.209 |
| 1.0000 | 1.0000 | 2733.85 | .12058 | .675 | 15858.0 | 25814.3 | 52.628 | 80.044 | 103.378 | 78.241 | 165.699 | 147.353 |

## TABLE A.1 - SATURATED VAPOR-LIQUID PROPERTIES FOR R-11/R-12 MIXTURE (Concluded)

DEW/BUBBLE LINES AT T = 373.1 K
COMPONENT A: R12    COMPONENT B: R11
MIXING COEFFICIENT, F = .0050

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 819.35 | .10763 | 3.171 | 17152.1 | 37160.5 | 56.995 | 110.615 | 114.568 | 78.676 | 133.801 | 96.179 |
| .1000 | .2486 | 1031.57 | .10777 | 2.466 | 17132.1 | 34977.5 | 59.459 | 109.827 | 113.872 | 77.885 | 133.955 | 97.244 |
| .2000 | .4175 | 1246.16 | .10807 | 1.993 | 17110.8 | 33404.8 | 60.691 | 106.652 | 113.118 | 77.523 | 134.336 | 99.126 |
| .3000 | .5413 | 1464.01 | .10859 | 1.651 | 17089.6 | 32170.1 | 61.401 | 103.324 | 112.298 | 77.418 | 135.032 | 101.742 |
| .4000 | .6374 | 1686.28 | .10939 | 1.392 | 17070.6 | 31134.7 | 61.733 | 100.083 | 111.400 | 77.492 | 136.173 | 105.157 |
| .5000 | .7156 | 1914.49 | .11053 | 1.186 | 17057.1 | 30218.0 | 61.748 | 96.937 | 110.408 | 77.705 | 137.971 | 109.568 |
| .6000 | .7819 | 2150.69 | .11215 | 1.018 | 17053.8 | 29366.9 | 61.476 | 93.835 | 109.297 | 78.041 | 140.785 | 115.349 |
| .7000 | .8405 | 2397.71 | .11442 | .875 | 17068.0 | 28540.3 | 60.921 | 90.694 | 108.037 | 78.503 | 145.277 | 123.202 |
| .8000 | .8943 | 2659.68 | .11765 | .750 | 17112.5 | 27699.5 | 60.068 | 87.392 | 106.574 | 79.111 | 152.807 | 134.532 |
| .9000 | .9464 | 2943.10 | .12243 | .637 | 17210.3 | 26796.6 | 58.840 | 83.720 | 104.820 | 79.915 | 166.664 | 152.604 |
| 1.0000 | 1.0000 | 3259.57 | .13003 | .531 | 17411.5 | 25751.2 | 56.668 | 79.018 | 102.595 | 81.037 | 197.385 | 187.299 |

## TABLE A.2 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-12 MIXTURE

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .200 MASS FRACTION R11
= .180 MOLE FRACTION R11

PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 247.24 | 1502.008 | 12.9 | .0833 | .7976 | .8885 | 348.6 |
| SAT VAP | 263.79 | 5.842 | 192.6 | .7945 | .4923 | .5689 | 138.2 |
| | 280.00 | 5.472 | 201.9 | .8289 | .5093 | .5845 | 142.8 |
| | 300.00 | 5.079 | 213.8 | .8699 | .5290 | .6028 | 148.1 |
| | 320.00 | 4.741 | 226.0 | .9093 | .5473 | .6200 | 153.2 |
| | 340.00 | 4.448 | 238.6 | .9474 | .5641 | .6360 | 158.0 |
| | 360.00 | 4.189 | 251.5 | .9842 | .5795 | .6507 | 162.7 |
| | 380.00 | 3.961 | 264.6 | 1.0197 | .5935 | .6640 | 167.2 |
| | 400.00 | 3.756 | 278.0 | 1.0541 | .6061 | .6761 | 171.6 |
| | 420.00 | 3.573 | 291.7 | 1.0873 | .6172 | .6868 | 175.9 |
| | 440.00 | 3.406 | 305.5 | 1.1195 | .6269 | .6962 | 180.0 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .400 MASS FRACTION R11
= .370 MOLE FRACTION R11

PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 252.57 | 1513.180 | 17.6 | .1127 | .7932 | .8799 | 358.8 |
| SAT VAP | 275.28 | 5.735 | 205.1 | .8268 | .5006 | .5751 | 139.2 |
| | 280.00 | 5.628 | 207.9 | .8366 | .5053 | .5794 | 140.5 |
| | 300.00 | 5.221 | 219.6 | .8772 | .5244 | .5970 | 145.8 |
| | 320.00 | 4.872 | 231.7 | .9162 | .5420 | .6135 | 150.9 |
| | 340.00 | 4.568 | 244.2 | .9537 | .5583 | .6288 | 155.7 |
| | 360.00 | 4.302 | 256.9 | .9902 | .5730 | .6428 | 160.4 |
| | 380.00 | 4.066 | 269.9 | 1.0253 | .5864 | .6556 | 164.9 |
| | 400.00 | 3.855 | 283.1 | 1.0593 | .5983 | .6670 | 169.2 |
| | 420.00 | 3.666 | 296.5 | 1.0921 | .6088 | .6771 | 173.5 |
| | 440.00 | 3.495 | 310.2 | 1.1238 | .6179 | .6858 | 177.6 |

## TABLE A.2 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-12 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .600 MASS FRACTION R11
= .569 MOLE FRACTION R11

PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 260.11 | 1518.588 | 23.9 | .1377 | .7899 | .8737 | 366.1 |
| SAT VAP | 283.71 | 5.712 | 215.9 | .8409 | .5048 | .5776 | 139.1 |
| | 300.00 | 5.373 | 225.4 | .8735 | .5198 | .5913 | 143.4 |
| | 320.00 | 5.010 | 237.4 | .9122 | .5368 | .6071 | 148.5 |
| | 340.00 | 4.696 | 249.7 | .9494 | .5524 | .6217 | 153.3 |
| | 360.00 | 4.421 | 262.3 | .9853 | .5666 | .6351 | 158.0 |
| | 380.00 | 4.177 | 275.1 | 1.0200 | .5793 | .6471 | 162.5 |
| | 400.00 | 3.960 | 288.2 | 1.0535 | .5906 | .6579 | 166.8 |
| | 420.00 | 3.765 | 301.4 | 1.0858 | .6005 | .6673 | 171.0 |
| | 440.00 | 3.589 | 314.8 | 1.1170 | .6090 | .6754 | 175.1 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .800 MASS FRACTION R11
= .779 MOLE FRACTION R11

PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 272.39 | 1512.775 | 33.9 | .1653 | .7896 | .8723 | 367.0 |
| SAT VAP | 290.59 | 5.733 | 225.8 | .8400 | .5069 | .5781 | 138.5 |
| | 300.00 | 5.534 | 231.2 | .8585 | .5151 | .5856 | 141.0 |
| | 320.00 | 5.158 | 243.1 | .8968 | .5315 | .6007 | 146.1 |
| | 340.00 | 4.833 | 255.3 | .9336 | .5465 | .6146 | 150.9 |
| | 360.00 | 4.547 | 267.7 | .9691 | .5601 | .6273 | 155.5 |
| | 380.00 | 4.296 | 280.3 | 1.0034 | .5722 | .6387 | 160.0 |
| | 400.00 | 4.071 | 293.2 | 1.0364 | .5829 | .6488 | 164.3 |
| | 420.00 | 3.870 | 306.3 | 1.0683 | .5922 | .6576 | 168.5 |
| | 440.00 | 3.688 | 319.5 | 1.0990 | .6000 | .6651 | 172.6 |

**TABLE A.2 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-12 MIXTURE (CONTINUED)**

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .200 MASS FRACTION R11
= .180 MOLE FRACTION R11

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 287.09 | 1387.575 | 49.4 | .2195 | .8317 | .9428 | 284.6 |
| SAT VAP | 301.80 | 21.746 | 210.4 | .7700 | .5360 | .6362 | 140.3 |
| | 320.00 | 20.134 | 222.1 | .8075 | .5524 | .6463 | 146.3 |
| | 340.00 | 18.661 | 235.1 | .8470 | .5690 | .6579 | 152.4 |
| | 360.00 | 17.418 | 248.4 | .8850 | .5842 | .6693 | 158.0 |
| | 380.00 | 16.351 | 261.9 | .9215 | .5980 | .6801 | 163.3 |
| | 400.00 | 15.421 | 275.6 | .9566 | .6103 | .6901 | 168.3 |
| | 420.00 | 14.602 | 289.5 | .9905 | .6213 | .6992 | 173.0 |
| | 440.00 | 13.874 | 303.5 | 1.0232 | .6309 | .7071 | 177.6 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .400 MASS FRACTION R11
= .370 MOLE FRACTION R11

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 294.32 | 1400.591 | 55.5 | .2507 | .8280 | .9320 | 293.6 |
| SAT VAP | 315.29 | 21.282 | 224.4 | .8065 | .5431 | .6398 | 141.5 |
| | 320.00 | 20.866 | 227.4 | .8160 | .5471 | .6422 | 143.0 |
| | 340.00 | 19.298 | 240.3 | .8552 | .5631 | .6525 | 149.3 |
| | 360.00 | 17.985 | 253.5 | .8928 | .5776 | .6629 | 155.0 |
| | 380.00 | 16.862 | 266.9 | .9289 | .5908 | .6728 | 160.4 |
| | 400.00 | 15.888 | 280.4 | .9637 | .6026 | .6820 | 165.4 |
| | 420.00 | 15.033 | 294.1 | .9971 | .6129 | .6902 | 170.2 |
| | 440.00 | 14.274 | 308.0 | 1.0294 | .6219 | .6975 | 174.8 |

## TABLE A.2 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-12 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .600 MASS FRACTION R11
= .569 MOLE FRACTION R11

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 304.19 | 1405.599 | 63.6 | .2779 | .8249 | .9249 | 299.3 |
| SAT VAP | 325.80 | 21.156 | 236.4 | .8248 | .5464 | .6411 | 141.5 |
| | 340.00 | 19.998 | 245.5 | .8523 | .5571 | .6475 | 146.0 |
| | 360.00 | 18.602 | 258.6 | .8896 | .5711 | .6567 | 151.9 |
| | 380.00 | 17.416 | 271.8 | .9253 | .5837 | .6657 | 157.3 |
| | 400.00 | 16.392 | 285.2 | .9597 | .5948 | .6740 | 162.5 |
| | 420.00 | 15.496 | 298.8 | .9928 | .6046 | .6814 | 167.3 |
| | 440.00 | 14.703 | 312.5 | 1.0246 | .6129 | .6879 | 171.9 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .800 MASS FRACTION R11
= .779 MOLE FRACTION R11

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 318.89 | 1397.289 | 75.8 | .3063 | .8232 | .9233 | 298.8 |
| SAT VAP | 334.67 | 21.219 | 247.3 | .8279 | .5475 | .6408 | 140.8 |
| | 340.00 | 20.771 | 250.7 | .8381 | .5512 | .6429 | 142.5 |
| | 360.00 | 19.279 | 263.6 | .8750 | .5646 | .6509 | 148.6 |
| | 380.00 | 18.020 | 276.7 | .9104 | .5765 | .6588 | 154.2 |
| | 400.00 | 16.938 | 290.0 | .9444 | .5871 | .6662 | 159.4 |
| | 420.00 | 15.996 | 303.4 | .9771 | .5962 | .6728 | 164.3 |
| | 440.00 | 15.164 | 316.9 | 1.0085 | .6039 | .6784 | 169.0 |

# TABLE A.2 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-12 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .200 MASS FRACTION R11
= .180 MOLE FRACTION R11

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 307.57 | 1321.961 | 69.1 | .2850 | .8446 | .9767 | 253.3 |
| SAT VAP | 321.13 | 37.614 | 218.4 | .7622 | .5590 | .6839 | 138.9 |
| | 340.00 | 34.479 | 231.3 | .8013 | .5742 | .6865 | 146.2 |
| | 360.00 | 31.809 | 245.1 | .8407 | .5891 | .6921 | 153.0 |
| | 380.00 | 29.605 | 259.0 | .8783 | .6026 | .6989 | 159.1 |
| | 400.00 | 27.743 | 273.0 | .9144 | .6148 | .7059 | 164.8 |
| | 420.00 | 26.139 | 287.2 | .9490 | .6256 | .7127 | 170.1 |
| | 440.00 | 24.739 | 301.5 | .9823 | .6350 | .7189 | 175.1 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .400 MASS FRACTION R11
= .370 MOLE FRACTION R11

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 315.87 | 1336.342 | 76.0 | .3171 | .8414 | .9634 | 261.7 |
| SAT VAP | 335.52 | 36.740 | 233.0 | .8005 | .5650 | .6848 | 140.3 |
| | 340.00 | 35.990 | 236.1 | .8096 | .5684 | .6851 | 142.1 |
| | 360.00 | 33.076 | 249.8 | .8488 | .5826 | .6884 | 149.2 |
| | 380.00 | 30.700 | 263.6 | .8861 | .5955 | .6935 | 155.6 |
| | 400.00 | 28.710 | 277.6 | .9219 | .6071 | .6993 | 161.4 |
| | 420.00 | 27.008 | 291.6 | .9561 | .6172 | .7050 | 166.9 |
| | 440.00 | 25.529 | 305.8 | .9890 | .6260 | .7102 | 172.0 |

## TABLE A.2 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-12 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .600 MASS FRACTION R11
= .569 MOLE FRACTION R11

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 326.93 | 1341.220 | 85.0 | .3452 | .8381 | .9552 | 266.7 |
| SAT VAP | 347.08 | 36.495 | 245.7 | .8207 | .5675 | .6849 | 140.3 |
| | 360.00 | 34.504 | 254.5 | .8457 | .5761 | .6856 | 145.1 |
| | 380.00 | 31.919 | 268.3 | .8829 | .5884 | .6888 | 151.8 |
| | 400.00 | 29.776 | 282.1 | .9183 | .5993 | .6931 | 157.9 |
| | 420.00 | 27.958 | 296.0 | .9522 | .6088 | .6976 | 163.5 |
| | 440.00 | 26.388 | 310.0 | .9848 | .6170 | .7018 | 168.7 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .800 MASS FRACTION R11
= .779 MOLE FRACTION R11

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 342.67 | 1331.530 | 98.1 | .3732 | .8352 | .9535 | 265.7 |
| SAT VAP | 357.01 | 36.618 | 257.1 | .8255 | .5678 | .6844 | 139.5 |
| | 360.00 | 36.135 | 259.1 | .8312 | .5697 | .6842 | 140.7 |
| | 380.00 | 33.289 | 272.8 | .8682 | .5813 | .6850 | 147.7 |
| | 400.00 | 30.962 | 286.5 | .9034 | .5916 | .6875 | 154.0 |
| | 420.00 | 29.006 | 300.3 | .9370 | .6005 | .6907 | 159.8 |
| | 440.00 | 27.329 | 314.1 | .9692 | .6080 | .6937 | 165.2 |

## TABLE A.2 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-12 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .200 MASS FRACTION R11
= .180 MOLE FRACTION R11

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 322.36 | 1270.304 | 83.8 | .3309 | .8517 | 1.0069 | 231.1 |
| SAT VAP | 334.99 | 53.918 | 223.4 | .7574 | .5763 | .7290 | 136.9 |
| | 340.00 | 52.479 | 227.0 | .7681 | .5801 | .7261 | 139.2 |
| | 360.00 | 47.661 | 241.5 | .8095 | .5945 | .7209 | 147.5 |
| | 380.00 | 43.890 | 255.9 | .8484 | .6076 | .7212 | 154.8 |
| | 400.00 | 40.818 | 270.3 | .8855 | .6195 | .7240 | 161.2 |
| | 420.00 | 38.242 | 284.9 | .9209 | .6300 | .7278 | 167.1 |
| | 440.00 | 36.038 | 299.5 | .9549 | .6392 | .7317 | 172.6 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .400 MASS FRACTION R11
= .370 MOLE FRACTION R11

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 331.47 | 1285.929 | 91.2 | .3636 | .8488 | .9908 | 239.2 |
| SAT VAP | 349.97 | 52.574 | 238.5 | .7967 | .5814 | .7267 | 138.4 |
| | 360.00 | 50.021 | 245.8 | .8172 | .5881 | .7224 | 142.8 |
| | 380.00 | 45.824 | 260.2 | .8561 | .6006 | .7192 | 150.5 |
| | 400.00 | 42.460 | 274.6 | .8930 | .6118 | .7197 | 157.3 |
| | 420.00 | 39.674 | 289.0 | .9282 | .6217 | .7217 | 163.4 |
| | 440.00 | 37.311 | 303.5 | .9618 | .6302 | .7243 | 169.0 |

## TABLE A.2 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-12 MIXTURE (Concluded).

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .600 MASS FRACTION R11
= .569 MOLE FRACTION R11

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 343.39 | 1290.747 | 101.0 | .3921 | .8454 | .9813 | 243.6 |
| SAT VAP | 362.27 | 52.199 | 251.6 | .8181 | .5832 | .7257 | 138.4 |
| | 380.00 | 48.049 | 264.4 | .8526 | .5935 | .7190 | 145.7 |
| | 400.00 | 44.319 | 278.7 | .8894 | .6041 | .7165 | 153.0 |
| | 420.00 | 41.275 | 293.1 | .9244 | .6133 | .7165 | 159.4 |
| | 440.00 | 38.720 | 307.4 | .9577 | .6212 | .7175 | 165.3 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R12
MIXING COEFFICIENT = .005
COMPOSITION = .800 MASS FRACTION R11
= .779 MOLE FRACTION R11

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 359.78 | 1279.943 | 114.7 | .4197 | .8414 | .9799 | 242.4 |
| SAT VAP | 373.00 | 52.409 | 263.3 | .8240 | .5828 | .7253 | 137.5 |
| | 380.00 | 50.658 | 268.4 | .8375 | .5866 | .7213 | 140.5 |
| | 400.00 | 46.449 | 282.8 | .8743 | .5964 | .7148 | 148.3 |
| | 420.00 | 43.082 | 297.0 | .9091 | .6050 | .7122 | 155.1 |
| | 440.00 | 40.293 | 311.3 | .9422 | .6123 | .7114 | 161.2 |

## TABLE A.3 - SATURATED VAPOR-LIQUID PROPERTIES OF R-11/R-22 MIXTURE

DEW/BUBBLE LINES AT T = 273.1 K
COMPONENT A: R22 COMPONENT B: R11
MIXING COEFFICIENT, F = .0370

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 40.12 | .08958 | 55.564 | 4603.2 | 30638.3 | 18.200 | 113.531 | 106.887 | 66.766 | 117.929 | 75.662 |
| .1000 | .6465 | 105.54 | .08772 | 20.907 | 4698.5 | 25144.3 | 20.841 | 103.733 | 104.152 | 53.528 | 115.692 | 62.846 |
| .2000 | .7898 | 163.62 | .08584 | 13.339 | 4766.5 | 23867.1 | 22.204 | 97.224 | 101.443 | 50.656 | 113.530 | 60.414 |
| .3000 | .8540 | 215.27 | .08391 | 10.037 | 4804.5 | 23259.1 | 22.990 | 93.255 | 98.766 | 49.406 | 111.455 | 59.587 |
| .4000 | .8915 | 261.46 | .08193 | 8.187 | 4809.2 | 22882.0 | 23.330 | 90.473 | 96.131 | 48.701 | 109.478 | 59.283 |
| .5000 | .9169 | 303.28 | .07989 | 6.998 | 4776.6 | 22610.8 | 23.267 | 88.341 | 93.551 | 48.238 | 107.612 | 59.202 |
| .6000 | .9362 | 341.92 | .07775 | 6.157 | 4701.7 | 22394.6 | 22.805 | 86.588 | 91.040 | 47.897 | 105.865 | 59.228 |
| .7000 | .9524 | 378.72 | .07549 | 5.517 | 4578.1 | 22207.1 | 21.915 | 85.047 | 88.621 | 47.617 | 104.245 | 59.312 |
| .8000 | .9674 | 415.25 | .07306 | 4.993 | 4397.9 | 22030.5 | 20.526 | 83.591 | 86.324 | 47.363 | 102.746 | 59.430 |
| .9000 | .9827 | 453.42 | .07041 | 4.537 | 4150.9 | 21849.6 | 18.474 | 82.090 | 84.189 | 47.105 | 101.348 | 59.573 |
| 1.0000 | 1.0000 | 495.71 | .06746 | 4.114 | 3823.7 | 21647.2 | 15.021 | 80.285 | 82.274 | 46.812 | 100.002 | 59.732 |

DEW/BUBBLE LINES AT T = 283.1 K
COMPONENT A: R22 COMPONENT B: R11
MIXING COEFFICIENT, F = .0370

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 60.51 | .09092 | 37.929 | 5790.4 | 31342.9 | 22.463 | 112.722 | 108.019 | 68.053 | 119.301 | 77.192 |
| .1000 | .6115 | 145.60 | .08911 | 15.579 | 5864.5 | 26000.4 | 25.021 | 103.706 | 105.284 | 55.480 | 117.122 | 65.133 |
| .2000 | .7642 | 222.09 | .08728 | 10.083 | 5911.9 | 24594.5 | 26.305 | 97.189 | 102.572 | 52.420 | 115.030 | 62.628 |
| .3000 | .8349 | 290.95 | .08542 | 7.603 | 5930.1 | 23898.4 | 27.014 | 93.091 | 99.890 | 51.052 | 113.037 | 61.806 |
| .4000 | .8769 | 353.30 | .08351 | 6.190 | 5915.8 | 23456.3 | 27.282 | 90.166 | 97.245 | 50.274 | 111.158 | 61.560 |
| .5000 | .9057 | 410.42 | .08153 | 5.272 | 5865.2 | 23132.9 | 27.150 | 87.893 | 94.650 | 49.761 | 109.410 | 61.568 |
| .6000 | .9277 | 463.75 | .07947 | 4.618 | 5773.4 | 22871.9 | 26.625 | 86.002 | 92.122 | 49.385 | 107.805 | 61.705 |
| .7000 | .9463 | 514.95 | .07728 | 4.118 | 5634.2 | 22643.4 | 25.676 | 84.325 | 89.680 | 49.078 | 106.353 | 61.916 |
| .8000 | .9634 | 565.98 | .07492 | 3.710 | 5439.6 | 22427.8 | 24.232 | 82.732 | 87.357 | 48.803 | 105.052 | 62.180 |
| .9000 | .9807 | 619.26 | .07233 | 3.356 | 5179.2 | 22208.0 | 22.129 | 81.089 | 85.194 | 48.527 | 103.875 | 62.491 |
| 1.0000 | 1.0000 | 677.94 | .06942 | 3.031 | 4839.0 | 21965.0 | 18.627 | 79.122 | 83.253 | 48.219 | 102.756 | 62.851 |

## TABLE A.3 - SATURATED VAPOR-LIQUID PROPERTIES OF R-11/R-22 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 293.1 K
COMPONENT A: R22    COMPONENT B: R11
MIXING COEFFICIENT, F = .0370

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 88.38 | .09233 | 26.659 | 6991.7 | 32044.4 | 26.624 | 112.099 | 109.075 | 69.306 | 120.677 | 78.760 |
| .1000 | .5773 | 196.58 | .09058 | 11.829 | 7045.3 | 26858.4 | 29.104 | 103.784 | 106.343 | 57.414 | 118.569 | 67.486 |
| .2000 | .7379 | 295.00 | .08881 | 7.766 | 7073.0 | 25330.3 | 30.313 | 97.282 | 103.629 | 54.205 | 116.559 | 64.965 |
| .3000 | .8149 | 384.67 | .08702 | 5.870 | 7072.2 | 24543.3 | 30.951 | 93.066 | 100.941 | 52.731 | 114.666 | 64.191 |
| .4000 | .8614 | 466.84 | .08519 | 4.770 | 7039.9 | 24031.4 | 31.150 | 89.998 | 98.285 | 51.886 | 112.908 | 64.045 |
| .5000 | .8937 | 542.96 | .08330 | 4.048 | 6972.5 | 23650.2 | 30.956 | 87.577 | 95.675 | 51.330 | 111.307 | 64.190 |
| .6000 | .9186 | 614.76 | .08133 | 3.530 | 6865.3 | 23338.3 | 30.373 | 85.540 | 93.124 | 50.923 | 109.884 | 64.494 |
| .7000 | .9396 | 684.26 | .07924 | 3.132 | 6712.1 | 23062.7 | 29.371 | 83.715 | 90.656 | 50.596 | 108.655 | 64.900 |
| .8000 | .9590 | 753.88 | .07698 | 2.807 | 6505.1 | 22801.3 | 27.880 | 81.971 | 88.300 | 50.305 | 107.621 | 65.389 |
| .9000 | .9785 | 826.63 | .07447 | 2.526 | 6233.4 | 22535.1 | 25.736 | 80.168 | 86.101 | 50.017 | 106.756 | 65.965 |
| 1.0000 | 1.0000 | 906.42 | .07162 | 2.271 | 5882.6 | 22243.5 | 22.194 | 78.014 | 84.124 | 49.700 | 105.972 | 66.642 |

DEW/BUBBLE LINES AT T = 303.1 K
COMPONENT A: R22    COMPONENT B: R11
MIXING COEFFICIENT, F = .0370

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 125.46 | .09382 | 19.223 | 8207.2 | 32739.7 | 30.690 | 111.628 | 110.055 | 70.529 | 122.067 | 80.386 |
| .1000 | .5441 | 260.32 | .09213 | 9.130 | 8241.2 | 27713.6 | 33.096 | 103.944 | 107.326 | 59.325 | 120.041 | 69.919 |
| .2000 | .7112 | 384.38 | .09043 | 6.079 | 8249.9 | 26071.1 | 34.234 | 97.481 | 104.611 | 56.007 | 118.131 | 67.447 |
| .3000 | .7941 | 498.71 | .08872 | 4.607 | 8231.2 | 25191.5 | 34.805 | 93.155 | 101.916 | 54.445 | 116.359 | 66.770 |
| .4000 | .8450 | 604.67 | .08698 | 3.738 | 8182.2 | 24605.3 | 34.943 | 89.945 | 99.249 | 53.544 | 114.751 | 66.779 |
| .5000 | .8808 | 703.93 | .08520 | 3.160 | 8099.4 | 24160.8 | 34.691 | 87.373 | 96.620 | 52.952 | 113.338 | 67.127 |
| .6000 | .9086 | 798.50 | .08335 | 2.742 | 7978.5 | 23791.6 | 34.056 | 85.180 | 94.044 | 52.524 | 112.151 | 67.676 |
| .7000 | .9323 | 890.81 | .08139 | 2.420 | 7813.5 | 23461.8 | 33.010 | 83.196 | 91.541 | 52.183 | 111.219 | 68.373 |
| .8000 | .9541 | 983.84 | .07926 | 2.157 | 7596.5 | 23146.8 | 31.481 | 81.284 | 89.144 | 51.884 | 110.557 | 69.207 |
| .9000 | .9760 | 1081.27 | .07688 | 1.929 | 7316.5 | 22825.4 | 29.304 | 79.299 | 86.897 | 51.594 | 110.142 | 70.197 |
| 1.0000 | 1.0000 | 1187.87 | .07412 | 1.724 | 6958.2 | 22475.0 | 25.733 | 76.927 | 84.871 | 51.278 | 109.866 | 71.386 |

## TABLE A.3 - SATURATED VAPOR-LIQUID PROPERTIES OF R-11/R-22 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 313.1 K

COMPONENT A: R22 COMPONENT B: R11

MIXING COEFFICIENT, F = .0370

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 173.66 | .09539 | 14.173 | 9437.1 | 33425.6 | 34.667 | 111.283 | 110.957 | 71.726 | 123.481 | 82.092 |
| .1000 | .5121 | 338.76 | .09377 | 7.151 | 9452.3 | 28561.5 | 37.004 | 104.168 | 108.231 | 61.214 | 121.553 | 72.452 |
| .2000 | .6842 | 492.28 | .09216 | 4.828 | 9443.1 | 26813.6 | 38.075 | 97.763 | 105.515 | 57.830 | 119.763 | 70.100 |
| .3000 | .7725 | 635.32 | .09055 | 3.669 | 9407.7 | 25840.7 | 38.584 | 93.338 | 102.813 | 56.199 | 118.139 | 69.581 |
| .4000 | .8277 | 769.35 | .08892 | 2.972 | 9343.4 | 25176.1 | 38.664 | 89.988 | 100.132 | 55.254 | 116.719 | 69.815 |
| .5000 | .8670 | 896.26 | .08727 | 2.503 | 9247.0 | 24662.7 | 38.362 | 87.262 | 97.481 | 54.638 | 115.546 | 70.452 |
| .6000 | .8979 | 1018.39 | .08557 | 2.161 | 9114.4 | 24229.7 | 37.683 | 84.906 | 94.874 | 54.198 | 114.670 | 71.356 |
| .7000 | .9242 | 1138.66 | .08377 | 1.896 | 8940.2 | 23837.9 | 36.601 | 82.748 | 92.329 | 53.855 | 114.146 | 72.484 |
| .8000 | .9486 | 1260.67 | .08182 | 1.678 | 8716.5 | 23460.1 | 35.044 | 80.648 | 89.879 | 53.561 | 114.013 | 73.846 |
| .9000 | .9732 | 1388.95 | .07962 | 1.491 | 8432.2 | 23072.7 | 32.847 | 78.455 | 87.569 | 53.281 | 114.270 | 75.494 |
| 1.0000 | 1.0000 | 1529.27 | .07703 | 1.323 | 8071.0 | 22650.7 | 29.261 | 75.827 | 85.474 | 52.982 | 114.800 | 77.527 |

DEW/BUBBLE LINES AT T = 323.1 K

COMPONENT A: R22 COMPONENT B: R11

MIXING COEFFICIENT, F = .0370

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 235.01 | .09706 | 10.655 | 10681.7 | 34098.9 | 38.561 | 111.038 | 111.777 | 72.902 | 124.933 | 83.905 |
| .1000 | .4812 | 433.93 | .09553 | 5.672 | 10679.1 | 29398.0 | 40.832 | 104.438 | 109.056 | 63.081 | 123.124 | 75.113 |
| .2000 | .6570 | 620.77 | .09401 | 3.882 | 10653.2 | 27554.4 | 41.842 | 98.110 | 106.338 | 59.673 | 121.479 | 72.959 |
| .3000 | .7501 | 796.70 | .09251 | 2.958 | 10602.4 | 26488.3 | 42.294 | 93.599 | 103.628 | 57.997 | 120.039 | 72.673 |
| .4000 | .8095 | 963.30 | .09103 | 2.393 | 10524.3 | 25742.0 | 42.322 | 90.113 | 100.931 | 57.024 | 118.856 | 73.220 |
| .5000 | .8522 | 1122.70 | .08954 | 2.007 | 10416.4 | 25154.1 | 41.976 | 87.229 | 98.253 | 56.398 | 117.995 | 74.262 |
| .6000 | .8861 | 1277.63 | .08802 | 1.724 | 10274.9 | 24650.1 | 41.261 | 84.699 | 95.607 | 55.960 | 117.538 | 75.676 |
| .7000 | .9153 | 1431.60 | .08644 | 1.503 | 10094.8 | 24187.6 | 40.152 | 82.353 | 93.010 | 55.630 | 117.581 | 77.444 |
| .8000 | .9425 | 1589.00 | .08474 | 1.320 | 9868.9 | 23736.3 | 38.581 | 80.045 | 90.491 | 55.358 | 118.225 | 79.622 |
| .9000 | .9700 | 1755.38 | .08281 | 1.163 | 9585.9 | 23269.7 | 36.381 | 77.610 | 88.097 | 55.108 | 119.532 | 82.341 |
| 1.0000 | 1.0000 | 1937.77 | .08046 | 1.023 | 9228.6 | 22759.2 | 32.799 | 74.677 | 85.906 | 54.848 | 121.412 | 85.819 |

## TABLE A.3 - SATURATED VAPOR-LIQUID PROPERTIES OF R-11/R-22 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 333.1 K
COMPONENT A: R22 COMPONENT B: R11
MIXING COEFFICIENT, F = .0370

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 311.69 | .09885 | 8.148 | 11941.4 | 34756.4 | 42.378 | 110.871 | 112.515 | 74.062 | 126.445 | 85.859 |
| .1000 | .4516 | 547.92 | .09741 | 4.550 | 11922.0 | 30219.1 | 44.587 | 104.739 | 109.798 | 64.928 | 124.778 | 77.939 |
| .2000 | .6296 | 771.94 | .09601 | 3.155 | 11880.8 | 28289.9 | 45.540 | 98.505 | 107.078 | 61.540 | 123.312 | 76.068 |
| .3000 | .7269 | 984.97 | .09465 | 2.412 | 11816.1 | 27131.7 | 45.940 | 93.920 | 104.357 | 59.843 | 122.102 | 76.106 |
| .4000 | .7902 | 1188.77 | .09332 | 1.948 | 11726.4 | 26300.7 | 45.923 | 90.302 | 101.640 | 58.862 | 121.223 | 77.083 |
| .5000 | .8364 | 1385.75 | .09203 | 1.627 | 11609.3 | 25633.0 | 45.539 | 87.259 | 98.929 | 58.243 | 120.775 | 78.686 |
| .6000 | .8733 | 1579.13 | .09076 | 1.390 | 11462.2 | 25050.7 | 44.797 | 84.548 | 96.235 | 57.827 | 120.891 | 80.829 |
| .7000 | .9054 | 1773.11 | .08947 | 1.202 | 11280.7 | 24507.8 | 43.675 | 81.998 | 93.571 | 57.530 | 121.751 | 83.556 |
| .8000 | .9356 | 1973.11 | .08811 | 1.048 | 11058.5 | 23970.2 | 42.106 | 79.454 | 90.963 | 57.304 | 123.579 | 87.026 |
| .9000 | .9663 | 2186.07 | .08657 | .914 | 10785.2 | 23407.2 | 39.925 | 76.738 | 88.455 | 57.113 | 126.609 | 91.548 |
| 1.0000 | 1.0000 | 2420.63 | .08464 | .794 | 10442.4 | 22785.3 | 36.377 | 73.432 | 86.126 | 56.928 | 130.922 | 97.663 |

DEW/BUBBLE LINES AT T = 343.1 K
COMPONENT A: R22 COMPONENT B: R11
MIXING COEFFICIENT, F = .0370

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 405.97 | .10078 | 6.324 | 13216.7 | 35394.6 | 46.122 | 110.762 | 113.166 | 75.212 | 128.043 | 87.998 |
| .1000 | .4232 | 682.86 | .09945 | 3.687 | 13181.9 | 31020.6 | 48.274 | 105.056 | 110.453 | 66.759 | 126.549 | 80.977 |
| .2000 | .6020 | 947.81 | .09818 | 2.589 | 13126.7 | 29016.4 | 49.174 | 98.932 | 107.729 | 63.433 | 125.305 | 79.487 |
| .3000 | .7030 | 1202.15 | .09698 | 1.985 | 13050.0 | 27768.2 | 49.528 | 94.288 | 104.996 | 61.744 | 124.388 | 79.961 |
| .4000 | .7699 | 1447.83 | .09585 | 1.601 | 12950.9 | 26850.1 | 49.472 | 90.544 | 102.252 | 60.777 | 123.906 | 81.518 |
| .5000 | .8193 | 1687.61 | .09481 | 1.332 | 12827.8 | 26097.5 | 49.059 | 87.340 | 99.502 | 60.187 | 124.014 | 83.899 |
| .6000 | .8593 | 1925.33 | .09384 | 1.130 | 12679.2 | 25429.0 | 48.302 | 84.440 | 96.747 | 59.816 | 124.938 | 87.095 |
| .7000 | .8944 | 2166.11 | .09294 | .970 | 12502.2 | 24794.5 | 47.182 | 81.668 | 93.998 | 59.580 | 127.012 | 91.282 |
| .8000 | .9276 | 2416.74 | .09208 | .836 | 12292.4 | 24155.1 | 45.637 | 78.858 | 91.271 | 59.434 | 130.732 | 96.857 |
| .9000 | .9619 | 2686.08 | .09114 | .720 | 12041.3 | 23473.1 | 43.508 | 75.806 | 88.603 | 59.348 | 136.795 | 104.601 |
| 1.0000 | 1.0000 | 2985.21 | .08992 | .616 | 11731.2 | 22706.6 | 40.043 | 72.032 | 86.070 | 59.297 | 145.976 | 115.992 |

## TABLE A.3 - SATURATED VAPOR-LIQUID PROPERTIES OF R-11/R-22 MIXTURE (Concluded).

DEW/BUBBLE LINES AT T = 353.1 K
COMPONENT A: R22 COMPONENT B: R11
MIXING COEFFICIENT, F = .0370

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 520.22 | .10286 | 4.973 | 14508.4 | 36010.1 | 49.800 | 110.694 | 113.728 | 76.358 | 129.763 | 90.376 |
| .1000 | .3959 | 840.92 | .10166 | 3.012 | 14459.6 | 31798.8 | 51.899 | 105.377 | 111.017 | 68.581 | 128.484 | 84.291 |
| .2000 | .5745 | 1150.40 | .10055 | 2.142 | 14392.1 | 29730.2 | 52.752 | 99.379 | 108.288 | 65.358 | 127.520 | 83.294 |
| .3000 | .6784 | 1450.09 | .09955 | 1.647 | 14305.6 | 28394.8 | 53.065 | 94.658 | 105.537 | 63.707 | 126.981 | 84.347 |
| .4000 | .7484 | 1742.24 | .09867 | 1.326 | 14199.8 | 27387.8 | 52.978 | 90.826 | 102.762 | 62.780 | 127.027 | 86.686 |
| .5000 | .8009 | 2030.06 | .09793 | 1.099 | 14074.7 | 26545.1 | 52.546 | 87.461 | 99.960 | 62.246 | 127.905 | 90.149 |
| .6000 | .8438 | 2318.14 | .09737 | .926 | 13930.0 | 25782.0 | 51.788 | 84.363 | 97.130 | 61.950 | 130.001 | 94.884 |
| .7000 | .8818 | 2612.81 | .09701 | .787 | 13765.7 | 25043.2 | 50.690 | 81.349 | 94.269 | 61.813 | 133.959 | 101.352 |
| .8000 | .9184 | 2922.75 | .09686 | .671 | 13581.0 | 24282.2 | 49.201 | 78.234 | 91.382 | 61.798 | 140.894 | 110.535 |
| .9000 | .9565 | 3259.70 | .09690 | .568 | 13372.6 | 23449.6 | 47.178 | 74.773 | 88.485 | 61.886 | 152.833 | 124.537 |
| 1.0000 | 1.0000 | 3638.86 | .09698 | .475 | 13129.0 | 22484.9 | 43.883 | 70.379 | 85.629 | 62.077 | 173.469 | 148.238 |

DEW/BUBBLE LINES AT T = 363.1 K
COMPONENT A: R22 COMPONENT B: R11
MIXING COEFFICIENT, F = .0370

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 656.89 | .10513 | 3.954 | 15817.6 | 36599.2 | 53.416 | 110.650 | 114.196 | 77.508 | 131.655 | 93.065 |
| .1000 | .3698 | 1024.31 | .10408 | 2.480 | 15756.2 | 32549.4 | 55.468 | 105.690 | 111.486 | 70.399 | 130.646 | 87.966 |
| .2000 | .5468 | 1381.62 | .10316 | 1.784 | 15678.5 | 30427.1 | 56.278 | 99.829 | 108.747 | 67.320 | 130.042 | 87.598 |
| .3000 | .6529 | 1730.48 | .10240 | 1.377 | 15584.7 | 29007.9 | 56.558 | 95.107 | 105.974 | 65.740 | 130.002 | 89.414 |
| .4000 | .7258 | 2073.46 | .10182 | 1.107 | 15475.9 | 27910.9 | 56.449 | 91.136 | 103.159 | 64.884 | 130.771 | 92.808 |
| .5000 | .7811 | 2414.34 | .10149 | .912 | 15353.5 | 26973.2 | 56.011 | 87.610 | 100.293 | 64.437 | 132.744 | 97.796 |
| .6000 | .8267 | 2758.66 | .10148 | .763 | 15220.1 | 26106.3 | 55.268 | 84.305 | 97.365 | 64.255 | 136.611 | 104.851 |
| .7000 | .8676 | 3114.31 | .10187 | .642 | 15080.2 | 25247.9 | 54.221 | 81.027 | 94.356 | 64.271 | 143.650 | 115.010 |
| .8000 | .9073 | 3492.57 | .10282 | .538 | 14940.6 | 24339.1 | 52.839 | 77.556 | 91.245 | 64.462 | 156.521 | 130.826 |
| .9000 | .9496 | 3909.66 | .10456 | .446 | 14812.0 | 23307.1 | 51.014 | 73.574 | 87.998 | 64.849 | 181.629 | 158.747 |
| 1.0000 | 1.0000 | 4388.87 | .10741 | .360 | 14710.8 | 22041.6 | 48.085 | 68.275 | 84.574 | 65.514 | 238.363 | 220.622 |

# TABLE A.4 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-22 MIXTURE

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .200 MASS FRACTION R11
= .136 MOLE FRACTION R11

PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 234.48 | 1428.699 | 4.9 | .0478 | .8595 | 1.0078 | 411.4 |
| SAT VAP | 254.42 | 4.538 | 238.7 | 1.0257 | .5017 | .6009 | 160.2 |
| | 260.00 | 4.433 | 242.1 | 1.0388 | .5088 | .6074 | 162.0 |
| | 280.00 | 4.094 | 254.5 | 1.0847 | .5333 | .6302 | 168.1 |
| | 300.00 | 3.806 | 267.3 | 1.1289 | .5568 | .6525 | 174.0 |
| | 320.00 | 3.557 | 280.6 | 1.1717 | .5794 | .6740 | 179.7 |
| | 340.00 | 3.339 | 294.3 | 1.2132 | .6011 | .6948 | 185.1 |
| | 360.00 | 3.148 | 308.4 | 1.2535 | .6218 | .7148 | 190.3 |
| | 380.00 | 2.977 | 322.8 | 1.2927 | .6415 | .7339 | 195.3 |
| | 400.00 | 2.825 | 337.7 | 1.3308 | .6602 | .7522 | 200.2 |
| | 420.00 | 2.688 | 352.9 | 1.3679 | .6780 | .7695 | 205.0 |
| | 440.00 | 2.563 | 368.5 | 1.4041 | .6948 | .7860 | 209.6 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .400 MASS FRACTION R11
= .296 MOLE FRACTION R11

PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 237.40 | 1451.590 | 9.5 | .0768 | .8288 | .9615 | 409.2 |
| SAT VAP | 268.21 | 4.678 | 240.1 | 1.0062 | .5098 | .6010 | 156.6 |
| | 280.00 | 4.466 | 247.3 | 1.0323 | .5232 | .6135 | 160.1 |
| | 300.00 | 4.148 | 259.8 | 1.0753 | .5452 | .6341 | 165.8 |
| | 320.00 | 3.875 | 272.7 | 1.1169 | .5661 | .6539 | 171.3 |
| | 340.00 | 3.637 | 285.9 | 1.1571 | .5860 | .6728 | 176.6 |
| | 360.00 | 3.427 | 299.6 | 1.1951 | .6047 | .6908 | 181.6 |
| | 380.00 | 3.241 | 313.6 | 1.2339 | .6224 | .7079 | 186.6 |
| | 400.00 | 3.074 | 327.9 | 1.2706 | .6389 | .7240 | 191.3 |
| | 420.00 | 2.924 | 342.5 | 1.3063 | .6545 | .7390 | 195.9 |
| | 440.00 | 2.789 | 357.4 | 1.3410 | .6689 | .7531 | 200.4 |

## TABLE A.4 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-22 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .600 MASS FRACTION R11
= .486 MOLE FRACTION R11

PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 241.85 | 1482.076 | 13.4 | .0948 | .8032 | .9184 | 408.3 |
| SAT VAP | 278.70 | 4.939 | 239.3 | .9648 | .5119 | .5956 | 151.3 |
| | 280.00 | 4.913 | 240.1 | .9676 | .5132 | .5969 | 151.6 |
| | 300.00 | 4.561 | 252.2 | 1.0094 | .5336 | .6158 | 157.2 |
| | 320.00 | 4.257 | 264.7 | 1.0498 | .5528 | .6338 | 162.6 |
| | 340.00 | 3.993 | 277.6 | 1.0887 | .5708 | .6509 | 167.7 |
| | 360.00 | 3.762 | 290.8 | 1.1264 | .5876 | .6669 | 172.6 |
| | 380.00 | 3.556 | 304.3 | 1.1628 | .6033 | .6819 | 177.4 |
| | 400.00 | 3.372 | 318.0 | 1.1982 | .6177 | .6958 | 182.0 |
| | 420.00 | 3.207 | 332.1 | 1.2324 | .6309 | .7086 | 186.5 |
| | 440.00 | 3.058 | 346.4 | 1.2657 | .6429 | .7202 | 190.8 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .800 MASS FRACTION R11
= .716 MOLE FRACTION R11

PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 251.78 | 1512.317 | 19.9 | .1136 | .7856 | .8830 | 402.9 |
| SAT VAP | 287.87 | 5.302 | 237.5 | .9055 | .5108 | .5874 | 144.9 |
| | 300.00 | 5.068 | 244.7 | .9300 | .5220 | .5977 | 148.2 |
| | 320.00 | 4.726 | 256.8 | .9691 | .5395 | .6140 | 153.4 |
| | 340.00 | 4.430 | 269.2 | 1.0068 | .5557 | .6291 | 158.3 |
| | 360.00 | 4.170 | 281.9 | 1.0431 | .5706 | .6432 | 163.1 |
| | 380.00 | 3.941 | 294.9 | 1.0783 | .5842 | .6561 | 167.7 |
| | 400.00 | 3.736 | 308.2 | 1.1122 | .5964 | .6677 | 172.2 |
| | 420.00 | 3.552 | 321.6 | 1.1450 | .6074 | .6782 | 176.5 |
| | 440.00 | 3.386 | 335.3 | 1.1768 | .6170 | .6874 | 180.7 |

## TABLE A.4 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-22 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .200 MASS FRACTION R11
= .136 MOLE FRACTION R11

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 270.23 | 1317.700 | 42.4 | .1953 | .9062 | 1.0835 | 340.4 |
| SAT VAP | 288.29 | 16.887 | 254.9 | .9682 | .5482 | .6727 | 163.4 |
| | 300.00 | 16.057 | 262.9 | .9952 | .5618 | .6820 | 167.6 |
| | 320.00 | 14.839 | 276.7 | 1.0397 | .5843 | .6987 | 174.4 |
| | 340.00 | 13.814 | 290.8 | 1.0826 | .6059 | .7158 | 180.8 |
| | 360.00 | 12.937 | 305.3 | 1.1240 | .6265 | .7329 | 186.7 |
| | 380.00 | 12.175 | 320.1 | 1.1641 | .6461 | .7498 | 192.4 |
| | 400.00 | 11.506 | 335.3 | 1.2029 | .6648 | .7662 | 197.7 |
| | 420.00 | 10.912 | 350.8 | 1.2407 | .6825 | .7820 | 202.9 |
| | 440.00 | 10.381 | 366.6 | 1.2774 | .6993 | .7972 | 207.9 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .400 MASS FRACTION R11
= .296 MOLE FRACTION R11

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 274.69 | 1341.732 | 46.7 | .2213 | .8737 | 1.0294 | 339.4 |
| SAT VAP | 304.89 | 17.315 | 258.3 | .9616 | .5553 | .6692 | 160.1 |
| | 320.00 | 16.295 | 268.5 | .9942 | .5709 | .6801 | 165.2 |
| | 340.00 | 15.141 | 282.3 | 1.0359 | .5906 | .6949 | 171.6 |
| | 360.00 | 14.159 | 296.3 | 1.0761 | .6093 | .7098 | 177.5 |
| | 380.00 | 13.310 | 310.7 | 1.1148 | .6268 | .7244 | 183.1 |
| | 400.00 | 12.567 | 325.3 | 1.1524 | .6434 | .7385 | 188.4 |
| | 420.00 | 11.909 | 340.2 | 1.1887 | .6588 | .7520 | 193.5 |
| | 440.00 | 11.323 | 355.4 | 1.2240 | .6731 | .7647 | 198.3 |

# TABLE A.4 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-22 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .600 MASS FRACTION R11
= .486 MOLE FRACTION R11

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 281.57 | 1372.968 | 51.2 | .2385 | .8465 | .9793 | 338.9 |
| SAT VAP | 318.37 | 18.226 | 259.2 | .9329 | .5561 | .6614 | 154.7 |
| | 320.00 | 18.107 | 260.2 | .9363 | .5576 | .6624 | 155.3 |
| | 340.00 | 16.778 | 273.6 | .9768 | .5754 | .6748 | 161.7 |
| | 360.00 | 15.657 | 287.2 | 1.0157 | .5921 | .6873 | 167.6 |
| | 380.00 | 14.694 | 301.1 | 1.0532 | .6076 | .6995 | 173.2 |
| | 400.00 | 13.856 | 315.2 | 1.0894 | .6220 | .7112 | 178.4 |
| | 420.00 | 13.118 | 329.6 | 1.1244 | .6351 | .7222 | 183.4 |
| | 440.00 | 12.462 | 344.1 | 1.1582 | .6470 | .7324 | 188.2 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .800 MASS FRACTION R11
= .716 MOLE FRACTION R11

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 295.91 | 1400.324 | 60.2 | .2602 | .8270 | .9391 | 332.0 |
| SAT VAP | 330.60 | 19.565 | 258.7 | .8856 | .5530 | .6513 | 147.9 |
| | 340.00 | 18.861 | 264.8 | .9039 | .5603 | .6558 | 150.9 |
| | 360.00 | 17.546 | 278.0 | .9417 | .5750 | .6656 | 156.9 |
| | 380.00 | 16.429 | 291.4 | .9779 | .5885 | .6753 | 162.5 |
| | 400.00 | 15.463 | 305.0 | 1.0128 | .6006 | .6845 | 167.8 |
| | 420.00 | 14.618 | 318.8 | 1.0464 | .6114 | .6929 | 172.7 |
| | 440.00 | 13.869 | 332.7 | 1.0788 | .6210 | .7005 | 177.5 |

## TABLE A.4 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-22 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .200 MASS FRACTION R11
= .136 MOLE FRACTION R11

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 288.38 | 1255.561 | 62.5 | .2666 | .9257 | 1.1318 | 306.1 |
| SAT VAP | 305.26 | 29.128 | 261.8 | .9462 | .5732 | .7240 | 162.8 |
| | 320.00 | 27.220 | 272.5 | .9804 | .5895 | .7298 | 168.8 |
| | 340.00 | 25.077 | 287.2 | 1.0250 | .6109 | .7408 | 176.3 |
| | 360.00 | 23.306 | 302.1 | 1.0677 | .6314 | .7537 | 183.0 |
| | 380.00 | 21.808 | 317.3 | 1.1088 | .6509 | .7674 | 189.3 |
| | 400.00 | 20.519 | 332.8 | 1.1485 | .6695 | .7814 | 195.2 |
| | 420.00 | 19.393 | 348.6 | 1.1870 | .6871 | .7953 | 200.8 |
| | 440.00 | 18.399 | 364.6 | 1.2243 | .7038 | .8090 | 206.1 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .400 MASS FRACTION R11
= .296 MOLE FRACTION R11

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 293.77 | 1280.419 | 66.8 | .2912 | .8926 | 1.0714 | 305.7 |
| SAT VAP | 323.09 | 29.780 | 266.2 | .9451 | .5792 | .7160 | 159.7 |
| | 340.00 | 27.702 | 278.4 | .9818 | .5956 | .7225 | 166.2 |
| | 360.00 | 25.664 | 292.9 | 1.0233 | .6141 | .7323 | 173.1 |
| | 380.00 | 23.957 | 307.7 | 1.0632 | .6315 | .7433 | 179.5 |
| | 400.00 | 22.500 | 322.6 | 1.1016 | .6479 | .7547 | 185.4 |
| | 420.00 | 21.235 | 337.8 | 1.1387 | .6632 | .7660 | 190.9 |
| | 440.00 | 20.124 | 353.3 | 1.1746 | .6775 | .7770 | 196.2 |

**TABLE A.4 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-22 MIXTURE (CONTINUED)**

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .600 MASS FRACTION R11
= .486 MOLE FRACTION R11

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 302.10 | 1312.050 | 71.7 | .3081 | .8648 | 1.0157 | 305.2 |
| SAT VAP | 338.13 | 31.311 | 268.0 | .9219 | .5789 | .7061 | 154.3 |
| | 340.00 | 31.058 | 269.3 | .9258 | .5805 | .7065 | 155.0 |
| | 360.00 | 28.635 | 283.5 | .9663 | .5969 | .7126 | 162.2 |
| | 380.00 | 26.638 | 297.8 | 1.0050 | .6123 | .7204 | 168.7 |
| | 400.00 | 24.951 | 312.3 | 1.0422 | .6264 | .7288 | 174.7 |
| | 420.00 | 23.500 | 326.9 | 1.0780 | .6394 | .7374 | 180.4 |
| | 440.00 | 22.234 | 341.8 | 1.1125 | .6512 | .7456 | 185.6 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .800 MASS FRACTION R11
= .716 MOLE FRACTION R11

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 318.84 | 1337.323 | 82.2 | .3310 | .8439 | .9718 | 297.5 |
| SAT VAP | 352.07 | 33.657 | 268.2 | .8798 | .5744 | .6949 | 147.1 |
| | 360.00 | 32.541 | 273.7 | .8953 | .5799 | .6957 | 150.0 |
| | 380.00 | 30.106 | 287.7 | .9330 | .5931 | .6994 | 156.9 |
| | 400.00 | 28.087 | 301.7 | .9690 | .6050 | .7044 | 163.1 |
| | 420.00 | 26.372 | 315.9 | 1.0035 | .6157 | .7098 | 168.8 |
| | 440.00 | 24.891 | 330.1 | 1.0366 | .6251 | .7151 | 174.2 |

## TABLE A.4 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-22 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .200 MASS FRACTION R11
= .136 MOLE FRACTION R11

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 301.39 | 1207.426 | 77.5 | .3166 | .9375 | 1.1744 | 282.0 |
| SAT VAP | 317.33 | 41.611 | 265.9 | .9317 | .5924 | .7719 | 161.4 |
| | 320.00 | 41.032 | 267.9 | .9381 | .5953 | .7712 | 162.7 |
| | 340.00 | 37.298 | 283.3 | .9849 | .6163 | .7715 | 171.5 |
| | 360.00 | 34.346 | 298.8 | 1.0291 | .6366 | .7778 | 179.2 |
| | 380.00 | 31.928 | 314.5 | 1.0714 | .6559 | .7871 | 186.2 |
| | 400.00 | 29.893 | 330.3 | 1.1121 | .6743 | .7980 | 192.6 |
| | 420.00 | 28.148 | 346.4 | 1.1513 | .6918 | .8095 | 198.6 |
| | 440.00 | 26.629 | 362.7 | 1.1892 | .7084 | .8213 | 204.2 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .400 MASS FRACTION R11
= .296 MOLE FRACTION R11

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 307.54 | 1233.040 | 81.8 | .3404 | .9042 | 1.1076 | 282.0 |
| SAT VAP | 335.92 | 42.442 | 271.0 | .9342 | .5973 | .7588 | 158.5 |
| | 340.00 | 41.613 | 274.1 | .9433 | .6011 | .7582 | 160.3 |
| | 360.00 | 38.098 | 289.3 | .9867 | .6193 | .7595 | 168.5 |
| | 380.00 | 35.271 | 304.5 | 1.0279 | .6364 | .7650 | 175.7 |
| | 400.00 | 32.924 | 319.9 | 1.0673 | .6526 | .7726 | 182.3 |
| | 420.00 | 30.931 | 335.4 | 1.1052 | .6678 | .7812 | 188.3 |
| | 440.00 | 29.209 | 351.1 | 1.1417 | .6819 | .7901 | 194.0 |

## TABLE A.4 - SUPERHEATED VAPOR PROPERTIES OF R-11/R-22 MIXTURE (Concluded).

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .600 MASS FRACTION R11
= .486 MOLE FRACTION R11

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 317.01 | 1264.958 | 87.1 | .3571 | .8761 | 1.0464 | 281.5 |
| SAT VAP | 352.10 | 44.592 | 273.5 | .9147 | .5959 | .7465 | 153.1 |
| | 360.00 | 42.990 | 279.4 | .9313 | .6022 | .7451 | 156.4 |
| | 380.00 | 39.550 | 294.3 | .9716 | .6172 | .7455 | 164.1 |
| | 400.00 | 36.752 | 309.2 | 1.0099 | .6311 | .7491 | 170.9 |
| | 420.00 | 34.411 | 324.2 | 1.0465 | .6439 | .7543 | 177.2 |
| | 440.00 | 32.410 | 339.4 | 1.0818 | .6555 | .7600 | 182.9 |

SUPERHEATED VAPOR PROPERTIES FOR R11 /R22
MIXING COEFFICIENT = .037
COMPOSITION = .800 MASS FRACTION R11
= .716 MOLE FRACTION R11

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 335.50 | 1288.347 | 98.6 | .3806 | .8539 | .9991 | 273.2 |
| SAT VAP | 367.34 | 48.012 | 274.3 | .8761 | .5902 | .7349 | 145.5 |
| | 380.00 | 45.317 | 283.6 | .9009 | .5982 | .7309 | 150.7 |
| | 400.00 | 41.801 | 298.2 | .9383 | .6098 | .7289 | 158.1 |
| | 420.00 | 38.931 | 312.8 | .9739 | .6202 | .7296 | 164.7 |
| | 440.00 | 36.520 | 327.4 | 1.0079 | .6293 | .7315 | 170.7 |

## TABLE A.5 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-115 MIXTURE

DEW/BUBBLE LINES AT T = 263.1 K
COMPONENT A: R115 COMPONENT B: R22
MIXING COEFFICIENT, F = -.2560

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 353.26 | .06570 | 5.696 | 2833.6 | 21296.5 | 11.363 | 81.538 | 81.200 | 45.461 | 97.571 | 57.102 |
| .1000 | .0799 | 334.17 | .06901 | 6.029 | 1944.1 | 20963.4 | 12.074 | 83.767 | 87.468 | 49.178 | 104.659 | 60.837 |
| .2000 | .2425 | 335.46 | .07297 | 5.969 | 1368.0 | 20232.0 | 12.270 | 84.766 | 93.076 | 56.797 | 111.569 | 68.892 |
| .3000 | .4533 | 371.74 | .07761 | 5.309 | 1067.1 | 19238.5 | 12.570 | 83.272 | 98.059 | 66.736 | 118.426 | 79.797 |
| .4000 | .6438 | 446.98 | .08306 | 4.318 | 1010.5 | 18271.2 | 13.056 | 79.633 | 102.444 | 75.820 | 125.407 | 90.464 |
| .5000 | .7797 | 556.68 | .08950 | 3.362 | 1174.8 | 17472.7 | 13.746 | 75.176 | 106.245 | 82.459 | 132.782 | 99.497 |
| .6000 | .8662 | 691.27 | .09730 | 2.602 | 1544.2 | 16822.3 | 14.650 | 70.819 | 109.464 | 86.887 | 141.000 | 107.455 |
| .7000 | .9197 | 839.46 | .10704 | 2.041 | 2113.2 | 16256.7 | 15.788 | 66.864 | 112.076 | 89.859 | 150.901 | 115.575 |
| .8000 | .9540 | 991.63 | .11986 | 1.631 | 2892.9 | 15724.8 | 17.206 | 63.286 | 114.021 | 92.004 | 164.336 | 125.312 |
| .9000 | .9782 | 1144.35 | .13827 | 1.319 | 3931.1 | 15179.0 | 19.013 | 59.862 | 115.148 | 93.768 | 186.567 | 139.069 |
| 1.0000 | 1.0000 | 1311.10 | .16993 | 1.047 | 5397.6 | 14507.9 | 21.220 | 55.847 | 115.016 | 95.630 | 242.687 | 165.489 |

DEW/BUBBLE LINES AT T = 273.1 K
COMPONENT A: R115 COMPONENT B: R22
MIXING COEFFICIENT, F = -.2560

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 495.71 | .06746 | 4.114 | 3823.7 | 21647.2 | 15.021 | 80.285 | 82.274 | 46.812 | 100.002 | 59.732 |
| .1000 | .0844 | 472.28 | .07091 | 4.321 | 3007.0 | 21327.5 | 16.003 | 82.639 | 88.830 | 50.824 | 107.512 | 63.827 |
| .2000 | .2440 | 476.78 | .07508 | 4.245 | 2502.2 | 20661.2 | 16.461 | 83.751 | 94.670 | 58.477 | 114.904 | 72.148 |
| .3000 | .4436 | 525.72 | .08004 | 3.781 | 2272.1 | 19771.5 | 17.020 | 82.595 | 99.832 | 68.139 | 122.339 | 83.207 |
| .4000 | .6246 | 622.76 | .08592 | 3.106 | 2287.7 | 18879.8 | 17.765 | 79.434 | 104.342 | 77.045 | 130.058 | 94.389 |
| .5000 | .7577 | 762.00 | .09300 | 2.446 | 2528.0 | 18093.4 | 18.723 | 75.340 | 108.212 | 83.812 | 138.452 | 104.660 |
| .6000 | .8460 | 932.15 | .10173 | 1.905 | 2981.2 | 17398.3 | 19.920 | 71.111 | 111.433 | 88.585 | 148.213 | 114.819 |
| .7000 | .9031 | 1120.31 | .11295 | 1.492 | 3649.2 | 16742.9 | 21.401 | 67.050 | 113.961 | 92.010 | 160.745 | 126.700 |
| .8000 | .9414 | 1316.01 | .12837 | 1.177 | 4559.4 | 16074.9 | 23.272 | 63.132 | 115.687 | 94.688 | 179.555 | 143.499 |
| .9000 | .9701 | 1517.48 | .15235 | .925 | 5807.0 | 15316.4 | 25.807 | 59.030 | 116.331 | 97.143 | 217.078 | 173.909 |
| 1.0000 | 1.0000 | 1754.18 | .20400 | .674 | 7819.6 | 14151.2 | 29.941 | 53.125 | 114.791 | 100.408 | 389.417 | 283.741 |

# TABLE A.5 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-115 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 283.1 K
COMPONENT A: R115 COMPONENT B: R22
MIXING COEFFICIENT, F = -.2560

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 677.94 | .06942 | 3.031 | 4839.0 | 21965.0 | 18.627 | 79.122 | 83.253 | 48.219 | 102.756 | 62.851 |
| .1000 | .0886 | 650.30 | .07303 | 3.159 | 4099.5 | 21660.5 | 19.886 | 81.599 | 90.077 | 52.528 | 110.724 | 67.357 |
| .2000 | .2447 | 659.71 | .07746 | 3.080 | 3670.6 | 21052.2 | 20.612 | 82.802 | 96.124 | 60.208 | 118.673 | 76.056 |
| .3000 | .4336 | 724.17 | .08279 | 2.744 | 3517.1 | 20248.1 | 21.438 | 81.916 | 101.436 | 69.621 | 126.819 | 87.500 |
| .4000 | .6052 | 846.59 | .08922 | 2.271 | 3611.9 | 19414.9 | 22.455 | 79.147 | 106.038 | 78.367 | 135.506 | 99.566 |
| .5000 | .7346 | 1019.50 | .09710 | 1.804 | 3937.4 | 18629.4 | 23.703 | 75.356 | 109.934 | 85.261 | 145.327 | 111.707 |
| .6000 | .8236 | 1229.82 | .10705 | 1.410 | 4487.6 | 17877.8 | 25.225 | 71.223 | 113.100 | 90.396 | 157.412 | 125.337 |
| .7000 | .8833 | 1463.15 | .12032 | 1.098 | 5276.1 | 17111.1 | 27.107 | 67.013 | 115.458 | 94.339 | 174.311 | 143.920 |
| .8000 | .9249 | 1708.37 | .13966 | .851 | 6359.1 | 16259.2 | 29.553 | 62.642 | 116.818 | 97.699 | 203.503 | 176.243 |
| .9000 | .9575 | 1966.31 | .17384 | .636 | 7937.5 | 15151.3 | 33.203 | 57.473 | 116.608 | 101.236 | 282.548 | 263.321 |

CRITICAL POINT OF PURE OR PSEUDO-PURE MATERIAL EXCEEDED IN BUBLT

PSEUDO-PURE COMPONENT CRITICAL POINT EXCEEDED

DEW/BUBBLE LINES AT T = 293.1 K
COMPONENT A: R115 COMPONENT B: R22
MIXING COEFFICIENT, F = -.2560

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 906.42 | .07162 | 2.271 | 5882.6 | 22243.5 | 22.194 | 78.014 | 84.124 | 49.700 | 105.972 | 66.642 |
| .1000 | .0925 | 875.05 | .07542 | 2.349 | 5224.7 | 21954.3 | 23.733 | 80.607 | 91.191 | 54.309 | 114.455 | 71.647 |
| .2000 | .2448 | 891.53 | .08017 | 2.272 | 4877.3 | 21395.5 | 24.737 | 81.873 | 97.417 | 62.019 | 123.085 | 80.908 |
| .3000 | .4234 | 974.61 | .08597 | 2.023 | 4806.8 | 20657.9 | 25.842 | 81.191 | 102.845 | 71.215 | 132.162 | 93.102 |
| .4000 | .5855 | 1126.03 | .09309 | 1.683 | 4989.4 | 19863.8 | 27.149 | 78.728 | 107.495 | 79.829 | 142.207 | 106.671 |
| .5000 | .7103 | 1336.44 | .10201 | 1.343 | 5412.2 | 19063.4 | 28.713 | 75.174 | 111.361 | 86.861 | 154.179 | 121.828 |
| .6000 | .7985 | 1590.81 | .11365 | 1.050 | 6078.2 | 18236.9 | 30.608 | 71.084 | 114.393 | 92.387 | 170.087 | 141.432 |
| .7000 | .8594 | 1873.00 | .12992 | .810 | 7020.7 | 17324.3 | 32.984 | 66.648 | 116.455 | 96.936 | 195.107 | 173.437 |
| .8000 | .9023 | 2170.43 | .15586 | .609 | 8353.6 | 16203.0 | 36.239 | 61.617 | 117.190 | 101.207 | 248.470 | 247.433 |

MIXTURE PRESSURE ITERATION IN BUBLT DID NOT CONVERGE
VOLUME ITERATION FOR INCIPIENT PHASE DID NOT CONVERGE

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| .9000 | .9346 | 2393.16 | .23188 | .244 | 11058.9 | 11441.9 | 43.727 | 44.104 | 113.638 | 114.616 | 850.437 | 618.626 |

CRITICAL POINT OF PURE OR PSEUDO-PURE MATERIAL EXCEEDED IN BUBLT

PSEUDO-PURE COMPONENT CRITICAL POINT EXCEEDED

## TABLE A.5 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-115 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 303.1 K
COMPONENT A: R115 COMPONENT B: R22
MIXING COEFFICIENT, F = -.2560

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL | FRAC A) | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- | ---------------- | (KJ/KG | MOL K) | ---------------- | |
| .0000 | .0000 | 1187.87 | .07612 | 1.724 | 6958.2 | 22475.0 | 25.733 | 76.927 | 84.871 | 51.278 | 109.866 | 71.386 |
| .1000 | .0959 | 1153.75 | .07817 | 1.769 | 6386.9 | 22199.8 | 27.560 | 79.621 | 92.151 | 56.193 | 118.967 | 77.033 |
| .2000 | .2442 | 1179.85 | .08331 | 1.699 | 6127.2 | 21679.5 | 28.851 | 80.919 | 98.521 | 63.942 | 128.489 | 87.171 |
| .3000 | .4126 | 1284.86 | .08971 | 1.509 | 6148.2 | 20988.1 | 30.250 | 80.374 | 104.021 | 72.961 | 138.883 | 100.718 |
| .4000 | .5651 | 1468.75 | .09774 | 1.258 | 6429.9 | 20210.8 | 31.871 | 78.129 | 108.664 | 81.482 | 150.993 | 116.897 |
| .5000 | .6842 | 1719.83 | .10809 | 1.006 | 6967.1 | 19373.4 | 33.793 | 74.728 | 112.423 | 88.682 | 166.522 | 137.321 |
| .6000 | .7701 | 2020.58 | .12218 | .784 | 7777.8 | 18441.5 | 36.139 | 70.596 | 115.203 | 94.650 | 189.487 | 168.460 |
| .7000 | .8296 | 2351.67 | .14333 | .593 | 8933.2 | 17321.5 | 39.180 | 65.787 | 116.756 | 99.937 | 232.401 | 232.410 |

MIXTURE PRESSURE ITERATION IN BUBLT DID NOT CONVERGE
VOLUME ITERATION FOR INCIPIENT PHASE DID NOT CONVERGE

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| .8000 | .8716 | 2579.67 | .19031 | .367 | 10941.8 | 15016.7 | 44.678 | 57.079 | 115.323 | 107.485 | 439.173 | 714.774 |

CRITICAL POINT OF PURE OR PSEUDO-PURE MATERIAL EXCEEDED IN BUBLT

PSEUDO-PURE COMPONENT CRITICAL POINT EXCEEDED

DEW/BUBBLE LINES AT T = 313.1 K
COMPONENT A: R115 COMPONENT B: R22
MIXING COEFFICIENT, F = -.2560

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL | FRAC A) | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- | ---------------- | (KJ/KG | MOL K) | ---------------- | |
| .0000 | .0000 | 1529.27 | .07703 | 1.323 | 8071.0 | 22650.7 | 29.261 | 75.827 | 85.474 | 52.982 | 114.800 | 77.527 |
| .1000 | .0988 | 1493.89 | .08137 | 1.346 | 7592.1 | 22385.7 | 31.384 | 78.603 | 92.930 | 58.216 | 124.703 | 84.068 |
| .2000 | .2427 | 1532.58 | .08703 | 1.282 | 7428.0 | 21890.6 | 32.976 | 79.893 | 99.399 | 66.023 | 135.501 | 95.633 |
| .3000 | .4012 | 1662.91 | .09423 | 1.134 | 7551.2 | 21222.5 | 34.691 | 79.414 | 104.915 | 74.916 | 147.932 | 111.619 |
| .4000 | .5438 | 1882.30 | .10351 | .945 | 7948.4 | 20434.6 | 36.664 | 77.287 | 109.474 | 83.398 | 163.518 | 132.572 |
| .5000 | .6559 | 2175.93 | .11596 | .754 | 8626.5 | 19527.1 | 39.013 | 73.929 | 113.012 | 90.816 | 185.696 | 163.265 |
| .6000 | .7369 | 2522.09 | .13397 | .581 | 9632.6 | 18436.0 | 41.950 | 69.607 | 115.347 | 97.317 | 224.106 | 220.829 |

MIXTURE PRESSURE ITERATION IN BUBLT DID NOT CONVERGE
VOLUME ITERATION FOR INCIPIENT PHASE DID NOT CONVERGE

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| .7000 | .7927 | 2825.97 | .16709 | .249 | 11225.3 | 13956.6 | 46.377 | 54.125 | 115.531 | 112.049 | 340.558 | 901.242 |

CRITICAL POINT OF PURE OR PSEUDO-PURE MATERIAL EXCEEDED IN BUBLT

PSEUDO-PURE COMPONENT CRITICAL POINT EXCEEDED

## TABLE A.5 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-115 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 323.1 K
COMPONENT A: R115    COMPONENT B: R22
MIXING COEFFICIENT, F = -.2560

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 1937.77 | .08046 | 1.023 | 9228.6 | 22759.2 | 32.799 | 74.677 | 85.906 | 54.848 | 121.412 | 85.819 |
| .1000 | .1013 | 1903.19 | .08521 | 1.032 | 8849.2 | 22498.0 | 35.229 | 77.506 | 93.491 | 60.423 | 132.473 | 93.721 |
| .2000 | .2403 | 1957.79 | .09155 | .973 | 8791.1 | 22011.2 | 37.141 | 78.741 | 100.002 | 68.320 | 145.298 | 107.752 |
| .3000 | .3888 | 2116.69 | .09987 | .856 | 9032.3 | 21338.6 | 39.208 | 78.244 | 105.456 | 77.153 | 161.261 | 128.341 |
| .4000 | .5209 | 2373.71 | .11100 | .710 | 9570.4 | 20503.2 | 41.597 | 76.115 | 109.817 | 85.673 | 183.539 | 158.949 |
| .5000 | .6242 | 2709.09 | .12681 | .561 | 10436.7 | 19470.9 | 44.500 | 72.630 | 112.945 | 93.407 | 220.624 | 213.478 |
| .6000 | .6960 | 3091.70 | .15230 | .421 | 11749.4 | 18104.3 | 48.347 | 67.794 | 114.437 | 100.638 | 304.440 | 352.237 |

CRITICAL POINT OF PURE OR PSEUDO-PURE MATERIAL EXCEEDED IN BUBLT

PSEUDO-PURE COMPONENT CRITICAL POINT EXCEEDED

DEW/BUBBLE LINES AT T = 333.1 K
COMPONENT A: R115    COMPONENT B: R22
MIXING COEFFICIENT, F = -.2560

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 2420.63 | .08464 | .794 | 10442.4 | 22785.3 | 36.377 | 73.432 | 86.126 | 56.928 | 130.922 | 97.663 |
| .1000 | .1032 | 2389.58 | .08995 | .793 | 10172.0 | 22517.4 | 39.130 | 76.274 | 93.780 | 62.879 | 143.893 | 107.864 |
| .2000 | .2368 | 2463.57 | .09727 | .740 | 10235.2 | 22016.4 | 41.397 | 77.391 | 100.251 | 70.919 | 160.399 | 126.557 |
| .3000 | .3750 | 2653.84 | .10726 | .645 | 10619.7 | 21302.0 | 43.876 | 76.767 | 105.526 | 79.782 | 183.506 | 156.824 |
| .4000 | .4955 | 2948.62 | .12143 | .529 | 11345.3 | 20360.8 | 46.803 | 74.458 | 109.497 | 88.466 | 221.588 | 210.875 |
| .5000 | .5866 | 3318.58 | .14373 | .408 | 12505.9 | 19088.9 | 50.554 | 70.509 | 111.822 | 96.724 | 304.868 | 341.914 |

CRITICAL POINT OF PURE OR PSEUDO-PURE MATERIAL EXCEEDED IN BUBLT

PSEUDO-PURE COMPONENT CRITICAL POINT EXCEEDED

## TABLE A.5 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-115 MIXTURE (Concluded).

DEW/BUBBLE LINES AT T = 343.1 K
COMPONENT A: R115 COMPONENT B: R22
MIXING COEFFICIENT, F = -.2560

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 2985.21 | .08992 | .616 | 11731.2 | 22706.6 | 40.043 | 72.032 | 86.070 | 59.297 | 145.976 | 115.992 |
| .1000 | .1044 | 2960.92 | .09605 | .608 | 11583.9 | 22415.2 | 43.149 | 74.831 | 93.710 | 65.680 | 162.681 | 130.658 |
| .2000 | .2320 | 3057.86 | .10491 | .560 | 11794.2 | 21866.0 | 45.830 | 75.733 | 100.017 | 73.949 | 187.243 | 159.602 |
| .3000 | .3591 | 3281.01 | .11775 | .480 | 12370.6 | 21049.2 | 48.846 | 74.810 | 104.908 | 82.993 | 228.755 | 215.078 |
| .4000 | .4655 | 3608.75 | .13799 | .383 | 13394.8 | 19879.7 | 52.610 | 71.960 | 108.070 | 92.102 | 321.524 | 352.280 |

CRITICAL POINT OF PURE OR PSEUDO-PURE MATERIAL EXCEEDED IN BUBLT

PSEUDO-PURE COMPONENT CRITICAL POINT EXCEEDED

DEW/BUBBLE LINES AT T = 353.1 K
COMPONENT A: R115 COMPONENT B: R22
MIXING COEFFICIENT, F = -.2560

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 3638.86 | .09698 | .475 | 13129.0 | 22484.9 | 43.883 | 70.379 | 85.629 | 62.077 | 173.469 | 148.238 |
| .1000 | .1049 | 3625.08 | .10447 | .462 | 13130.6 | 22140.5 | 47.400 | 73.042 | 93.121 | 68.996 | 199.519 | 173.747 |
| .2000 | .2255 | 3748.01 | .11613 | .417 | 13541.6 | 21480.6 | 50.630 | 73.555 | 99.036 | 77.663 | 248.136 | 232.759 |
| .3000 | .3392 | 4002.01 | .13518 | .345 | 14438 6 | 20421.2 | 54.523 | 71.930 | 103.058 | 87.226 | 367.433 | 395.372 |

CRITICAL POINT OF PURE OR PSEUDO-PURE MATERIAL EXCEEDED IN BUBLT

PSEUDO-PURE COMPONENT CRITICAL POINT EXCEEDED

**TABLE A.6 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-115 MIXTURE**

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .200 MASS FRACTION R22
= .309 MOLE FRACTION R22
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 208.24 | 1542.994 | -39.2 | -.1119 | .7285 | .8921 | 329.4 |
| SAT VAP | 226.97 | 7.366 | 118.0 | .6074 | .5298 | .6035 | 121.8 |
| | 240.00 | 6.918 | 126.0 | .[illegible]16 | .5480 | .6201 | 125.7 |
| | 260.00 | 6.335 | 138.6 | .6922 | .5747 | .6450 | 131.4 |
| | 280.00 | 5.847 | 151.8 | .7409 | .6000 | .6688 | 136.7 |
| | 300.00 | 5.433 | 165.4 | .7878 | .6240 | .6916 | 141.8 |
| | 320.00 | 5.076 | 179.4 | .8331 | .6465 | .7133 | 146.6 |
| | 340.00 | 4.765 | 193.9 | .8770 | .6677 | .7337 | 151.2 |
| | 360.00 | 4.491 | 208.8 | .9195 | .6875 | .7528 | 155.6 |
| | 380.00 | 4.248 | 224.0 | .9607 | .7059 | .7707 | 159.9 |
| | 400.00 | 4.031 | 239.6 | 1.0006 | .7229 | .7872 | 164.0 |
| | 420.00 | 3.836 | 255.5 | 1.0394 | .7385 | .8025 | 168.0 |
| | 440.00 | 3.659 | 271.7 | 1.0771 | .7528 | .8164 | 171.9 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .400 MASS FRACTION R22
= .544 MOLE FRACTION R22
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 222.54 | 1528.772 | -32.7 | -.0570 | .8092 | .9648 | 355.4 |
| SAT VAP | 231.95 | 6.330 | 148.7 | .7350 | .5225 | .6051 | 132.6 |
| | 240.00 | 6.093 | 153.6 | .7558 | .5336 | .6152 | 135.2 |
| | 260.00 | 5.580 | 166.1 | .8060 | .5604 | .6399 | 141.2 |
| | 280.00 | 5.151 | 179.2 | .8543 | .5859 | .6639 | 146.8 |
| | 300.00 | 4.786 | 192.7 | .9009 | .6101 | .6869 | 152.1 |
| | 320.00 | 4.472 | 206.6 | .9460 | .6331 | .7089 | 157.2 |
| | 340.00 | 4.198 | 221.0 | .9896 | .6549 | .7298 | 162.1 |
| | 360.00 | 3.957 | 235.8 | 1.0319 | .6754 | .7496 | 166.8 |
| | 380.00 | 3.742 | 251.0 | 1.0729 | .6946 | .7682 | 171.4 |
| | 400.00 | 3.551 | 266.5 | 1.1127 | .7126 | .7858 | 175.8 |
| | 420.00 | 3.379 | 282.4 | 1.1515 | .7293 | .8021 | 180.1 |
| | 440.00 | 3.223 | 298.6 | 1.1891 | .7448 | .8172 | 184.2 |

## TABLE A.6 - SUPERHEATED VAPOR PROPS. OF R-22/R-115 MIXTURE (Continued)

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .600 MASS FRACTION R22
= .728 MOLE FRACTION R22
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 232.56 | 1490.107 | -21.8 | -.0117 | .8638 | 1.0185 | 372.4 |
| SAT VAP | 233.88 | 5.594 | 177.5 | .8419 | .5109 | .6022 | 142.5 |
| | 240.00 | 5.436 | 181.2 | .8576 | .5193 | .6098 | 144.5 |
| | 260.00 | 4.980 | 193.7 | .9074 | .5461 | .6345 | 150.8 |
| | 280.00 | 4.599 | 206.6 | .9553 | .5717 | .6585 | 156.7 |
| | 300.00 | 4.274 | 220.0 | 1.0015 | .5963 | .6818 | 162.3 |
| | 320.00 | 3.994 | 233.9 | 1.0462 | .6197 | .7042 | 167.6 |
| | 340.00 | 3.749 | 248.2 | 1.0896 | .6420 | .7256 | 172.8 |
| | 360.00 | 3.534 | 262.9 | 1.1316 | .6632 | .7461 | 177.7 |
| | 380.00 | 3.343 | 278.0 | 1.1725 | .6833 | .7656 | 182.5 |
| | 400.00 | 3.172 | 293.5 | 1.2122 | .7023 | .7841 | 187.1 |
| | 420.00 | 3.018 | 309.4 | 1.2509 | .7201 | .8015 | 191.6 |
| | 440.00 | 2.879 | 325.6 | 1.2886 | .7368 | .8179 | 196.0 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .800 MASS FRACTION R22
= .877 MOLE FRACTION R22
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 233.98 | 1455.852 | -12.7 | .0016 | .8870 | 1.0430 | 395.5 |
| SAT VAP | 234.14 | 5.038 | 205.4 | .9334 | .4968 | .5968 | 151.8 |
| | 240.00 | 4.902 | 209.0 | .9482 | .5049 | .6041 | 153.7 |
| | 260.00 | 4.494 | 221.3 | .9976 | .5317 | .6287 | 160.2 |
| | 280.00 | 4.151 | 234.1 | 1.0450 | .5575 | .6529 | 166.4 |
| | 300.00 | 3.859 | 247.4 | 1.0909 | .5824 | .6765 | 172.2 |
| | 320.00 | 3.607 | 261.2 | 1.1353 | .6062 | .6993 | 177.8 |
| | 340.00 | 3.387 | 275.4 | 1.1784 | .6291 | .7213 | 183.1 |
| | 360.00 | 3.193 | 290.0 | 1.2202 | .6510 | .7425 | 188.3 |
| | 380.00 | 3.020 | 305.1 | 1.2609 | .6719 | .7629 | 193.3 |
| | 400.00 | 2.866 | 320.5 | 1.3005 | .6919 | .7823 | 198.1 |
| | 420.00 | 2.727 | 336.3 | 1.3391 | .7108 | .8008 | 202.8 |
| | 440.00 | 2.601 | 352.5 | 1.3768 | .7288 | .8185 | 207.4 |

## TABLE A.6 - SUPERHEATED VAPOR PROPS. OF R-22/R-115 MIXTURE (Continued)

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .200 MASS FRACTION R22
= .309 MOLE FRACTION R22

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 241.09 | 1383.427 | -7.9 | .0261 | .7993 | 1.0110 | 263.4 |
| SAT VAP | 258.42 | 27.927 | 133.0 | .5889 | .5776 | .6831 | 122.1 |
| | 260.00 | 27.679 | 134.1 | .5931 | .5797 | .6842 | 122.7 |
| | 280.00 | 24.956 | 147.9 | .6443 | .6054 | .6996 | 130.1 |
| | 300.00 | 22.814 | 162.1 | .6932 | .6296 | .7169 | 136.7 |
| | 320.00 | 21.067 | 176.6 | .7400 | .6523 | .7346 | 142.6 |
| | 340.00 | 19.606 | 191.4 | .7851 | .6737 | .7521 | 148.1 |
| | 360.00 | 18.361 | 206.6 | .8285 | .6936 | .7689 | 153.2 |
| | 380.00 | 17.283 | 222.2 | .8705 | .7120 | .7849 | 157.9 |
| | 400.00 | 16.339 | 238.0 | .9112 | .7291 | .7999 | 162.5 |
| | 420.00 | 15.503 | 254.2 | .9505 | .7447 | .8139 | 166.8 |
| | 440.00 | 14.756 | 270.6 | .9887 | .7589 | .8266 | 170.9 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .400 MASS FRACTION R22
= .544 MOLE FRACTION R22

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 256.31 | 1388.773 | 1.8 | .0860 | .8785 | 1.0753 | 286.7 |
| SAT VAP | 265.05 | 23.781 | 164.4 | .7069 | .5722 | .6865 | 133.9 |
| | 280.00 | 22.044 | 174.8 | .7449 | .5913 | .6977 | 139.6 |
| | 300.00 | 20.150 | 188.9 | .7936 | .6157 | .7145 | 146.5 |
| | 320.00 | 18.605 | 203.4 | .8403 | .6389 | .7321 | 152.8 |
| | 340.00 | 17.312 | 218.2 | .8852 | .6607 | .7497 | 158.6 |
| | 360.00 | 16.209 | 233.3 | .9285 | .6813 | .7669 | 164.0 |
| | 380.00 | 15.254 | 248.9 | .9705 | .7006 | .7836 | 169.1 |
| | 400.00 | 14.418 | 264.7 | 1.0111 | .7186 | .7994 | 173.9 |
| | 420.00 | 13.677 | 280.8 | 1.0504 | .7353 | .8143 | 178.5 |
| | 440.00 | 13.015 | 297.2 | 1.0886 | .7508 | .8282 | 183.0 |

## TABLE A.6 - SUPERHEATED VAPOR PROPS. OF R-22/R-115 MIXTURE (Continued)

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .600 MASS FRACTION R22
= .728 MOLE FRACTION R22

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 266.23 | 1364.332 | 14.2 | .1319 | .9268 | 1.1206 | 303.4 |
| SAT VAP | 267.76 | 20.883 | 193.5 | .8027 | .5615 | .6843 | 144.5 |
| | 280.00 | 19.656 | 201.9 | .8335 | .5771 | .6936 | 149.3 |
| | 300.00 | 17.985 | 216.0 | .8819 | .6018 | .7104 | 156.5 |
| | 320.00 | 16.617 | 230.4 | .9284 | .6253 | .7282 | 163.0 |
| | 340.00 | 15.468 | 245.1 | .9730 | .6477 | .7462 | 169.0 |
| | 360.00 | 14.487 | 260.2 | 1.0162 | .6689 | .7640 | 174.7 |
| | 380.00 | 13.635 | 275.7 | 1.0580 | .6890 | .7814 | 180.0 |
| | 400.00 | 12.888 | 291.5 | 1.0985 | .7079 | .7981 | 185.1 |
| | 420.00 | 12.226 | 307.6 | 1.1378 | .7257 | .8140 | 190.0 |
| | 440.00 | 11.634 | 324.0 | 1.1760 | .7424 | .8291 | 194.6 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .800 MASS FRACTION R22
= .877 MOLE FRACTION R22

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 268.36 | 1338.259 | 24.8 | .1500 | .9446 | 1.1365 | 324.1 |
| SAT VAP | 268.39 | 18.707 | 221.4 | .8824 | .5479 | .6789 | 154.5 |
| | 280.00 | 17.687 | 229.3 | .9114 | .5628 | .6879 | 159.1 |
| | 300.00 | 16.207 | 243.2 | .9594 | .5877 | .7051 | 166.4 |
| | 320.00 | 14.989 | 257.5 | 1.0055 | .6116 | .7234 | 173.1 |
| | 340.00 | 13.962 | 272.2 | 1.0499 | .6344 | .7419 | 179.3 |
| | 360.00 | 13.082 | 287.2 | 1.0928 | .6563 | .7604 | 185.2 |
| | 380.00 | 12.318 | 302.6 | 1.1344 | .6772 | .7786 | 190.7 |
| | 400.00 | 11.645 | 318.3 | 1.1748 | .6971 | .7963 | 196.0 |
| | 420.00 | 11.048 | 334.4 | 1.2141 | .7161 | .8133 | 201.1 |
| | 440.00 | 10.514 | 350.9 | 1.2523 | .7340 | .8297 | 205.9 |

## TABLE A.6 - SUPERHEATED VAPOR PROPS. OF R-22/R-115 MIXTURE (Continued)

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .200 MASS FRACTION R22
= .309 MOLE FRACTION R22

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 257.71 | 1290.843 | 9.5 | .0950 | .8295 | 1.0914 | 231.3 |
| SAT VAP | 273.89 | 49.107 | 138.9 | .5811 | .6037 | .7468 | 119.7 |
| | 280.00 | 47.204 | 143.5 | .5976 | .6114 | .7458 | 122.7 |
| | 300.00 | 42.176 | 158.4 | .6492 | .6357 | .7501 | 131.2 |
| | 320.00 | 38.376 | 173.5 | .6979 | .6585 | .7604 | 138.5 |
| | 340.00 | 35.354 | 188.9 | .7444 | .6799 | .7731 | 144.9 |
| | 360.00 | 32.869 | 204.5 | .7889 | .6998 | .7866 | 150.7 |
| | 380.00 | 30.776 | 220.3 | .8318 | .7183 | .8001 | 156.0 |
| | 400.00 | 28.980 | 236.5 | .8732 | .7353 | .8132 | 160.9 |
| | 420.00 | 27.416 | 252.9 | .9132 | .7509 | .8256 | 165.5 |
| | 440.00 | 26.038 | 269.5 | .9518 | .7650 | .8371 | 169.9 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .400 MASS FRACTION R22
= .544 MOLE FRACTION R22

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 273.25 | 1308.636 | 20.6 | .1562 | .9074 | 1.1468 | 253.6 |
| SAT VAP | 281.51 | 41.497 | 170.9 | .6960 | .5994 | .7496 | 132.1 |
| | 300.00 | 37.395 | 184.7 | .7437 | .6219 | .7518 | 140.4 |
| | 320.00 | 34.001 | 199.9 | .7925 | .6451 | .7608 | 148.1 |
| | 340.00 | 31.305 | 215.2 | .8390 | .6669 | .7729 | 155.0 |
| | 360.00 | 29.089 | 230.8 | .8835 | .6875 | .7864 | 161.1 |
| | 380.00 | 27.223 | 246.7 | .9264 | .7067 | .8002 | 166.8 |
| | 400.00 | 25.622 | 262.8 | .9678 | .7247 | .8138 | 172.1 |
| | 420.00 | 24.228 | 279.2 | 1.0078 | .7414 | .8270 | 177.0 |
| | 440.00 | 22.999 | 295.9 | 1.0466 | .7567 | .8395 | 181.7 |

## TABLE A.6 - SUPERHEATED VAPOR PROPS. OF R-22/R-115 MIXTURE (Continued)

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .600 MASS FRACTION R22
= .728 MOLE FRACTION R22

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 283.10 | 1292.743 | 33.7 | .2019 | .9529 | 1.1861 | 270.0 |
| SAT VAP | 284.72 | 36.252 | 200.1 | .7876 | .5892 | .7466 | 143.2 |
| | 300.00 | 33.363 | 211.5 | .8267 | .6078 | .7490 | 150.1 |
| | 320.00 | 30.373 | 226.6 | .8753 | .6313 | .7580 | 158.1 |
| | 340.00 | 27.985 | 241.9 | .9216 | .6536 | .7703 | 165.2 |
| | 360.00 | 26.015 | 257.4 | .9660 | .6748 | .7842 | 171.6 |
| | 380.00 | 24.352 | 273.2 | 1.0088 | .6948 | .7986 | 177.5 |
| | 400.00 | 22.921 | 289.4 | 1.0501 | .7137 | .8130 | 183.0 |
| | 420.00 | 21.674 | 305.8 | 1.0901 | .7315 | .8272 | 188.3 |
| | 440.00 | 20.574 | 322.4 | 1.1289 | .7481 | .8408 | 193.2 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .800 MASS FRACTION R22
= .877 MOLE FRACTION R22

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 285.60 | 1271.902 | 44.9 | .2218 | .9684 | 1.1964 | 289.7 |
| SAT VAP | 285.61 | 32.342 | 228.0 | .8628 | .5758 | .7401 | 153.6 |
| | 300.00 | 29.988 | 238.6 | .8992 | .5935 | .7433 | 160.1 |
| | 320.00 | 27.358 | 253.6 | .9475 | .6172 | .7530 | 168.2 |
| | 340.00 | 25.241 | 268.8 | .9935 | .6400 | .7660 | 175.4 |
| | 360.00 | 23.486 | 284.3 | 1.0377 | .6618 | .7806 | 182.0 |
| | 380.00 | 21.997 | 300.0 | 1.0803 | .6827 | .7958 | 188.1 |
| | 400.00 | 20.713 | 316.1 | 1.1215 | .7025 | .8112 | 193.8 |
| | 420.00 | 19.590 | 332.5 | 1.1615 | .7214 | .8265 | 199.3 |
| | 440.00 | 18.598 | 349.1 | 1.2003 | .7392 | .8413 | 204.4 |

## TABLE A.6 - SUPERHEATED VAPOR PROPS. OF R-22/R-115 MIXTURE (Continued)

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .200 MASS FRACTION R22
= .309 MOLE FRACTION R22

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 269.61 | 1216.836 | 22.8 | .1446 | .8476 | 1.1675 | 208.5 |
| SAT VAP | 284.72 | 71.560 | 142.1 | .5746 | .6243 | .8142 | 116.9 |
| | 300.00 | 64.208 | 154.4 | .6166 | .6425 | .7964 | 125.3 |
| | 320.00 | 57.295 | 170.3 | .6678 | .6651 | .7925 | 134.2 |
| | 340.00 | 52.141 | 186.2 | .7160 | .6864 | .7974 | 141.7 |
| | 360.00 | 48.079 | 202.2 | .7618 | .7063 | .8061 | 148.2 |
| | 380.00 | 44.757 | 218.4 | .8057 | .7247 | .8164 | 154.1 |
| | 400.00 | 41.969 | 234.9 | .8478 | .7417 | .8271 | 159.4 |
| | 420.00 | 39.583 | 251.5 | .8884 | .7572 | .8376 | 164.3 |
| | 440.00 | 37.508 | 268.4 | .9276 | .7712 | .8477 | 168.8 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .400 MASS FRACTION R22
= .544 MOLE FRACTION R22

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 285.32 | 1245.297 | 34.7 | .2060 | .9248 | 1.2119 | 230.2 |
| SAT VAP | 293.16 | 60.002 | 174.5 | .6879 | .6209 | .8139 | 129.7 |
| | 300.00 | 57.265 | 180.1 | .7066 | .6289 | .8058 | 133.5 |
| | 320.00 | 50.987 | 196.1 | .7582 | .6517 | .7975 | 143.1 |
| | 340.00 | 46.333 | 212.1 | .8066 | .6734 | .8005 | 151.1 |
| | 360.00 | 42.675 | 228.1 | .8526 | .6939 | .8082 | 158.2 |
| | 380.00 | 39.689 | 244.4 | .8966 | .7131 | .8182 | 164.4 |
| | 400.00 | 37.185 | 260.9 | .9388 | .7309 | .8291 | 170.2 |
| | 420.00 | 35.044 | 277.6 | .9795 | .7475 | .8402 | 175.5 |
| | 440.00 | 33.183 | 294.5 | 1.0189 | .7628 | .8511 | 180.4 |

## TABLE A.6 - SUPERHEATED VAPOR PROPS. OF R-22/R-115 MIXTURE (Concluded).

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .600 MASS FRACTION R22
= .728 MOLE FRACTION R22

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 295.11 | 1236.512 | 48.2 | .2514 | .9685 | 1.2451 | 246.5 |
| SAT VAP | 296.78 | 52.157 | 203.9 | .7771 | .6109 | .8084 | 141.2 |
| | 300.00 | 51.075 | 206.5 | .7858 | .6147 | .8050 | 143.0 |
| | 320.00 | 45.564 | 222.5 | .8374 | .6378 | .7963 | 152.8 |
| | 340.00 | 41.448 | 238.5 | .8857 | .6599 | .7991 | 161.1 |
| | 360.00 | 38.197 | 254.5 | .9316 | .6809 | .8070 | 168.4 |
| | 380.00 | 35.534 | 270.8 | .9755 | .7009 | .8174 | 175.0 |
| | 400.00 | 33.295 | 287.2 | 1.0178 | .7197 | .8290 | 181.0 |
| | 420.00 | 31.376 | 303.9 | 1.0585 | .7373 | .8409 | 186.5 |
| | 440.00 | 29.706 | 320.9 | 1.0979 | .7538 | .8529 | 191.7 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R115
MIXING COEFFICIENT = -.256
COMPOSITION = .800 MASS FRACTION R22
= .877 MOLE FRACTION R22

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 297.88 | 1220.137 | 59.9 | .2724 | .9827 | 1.2499 | 265.6 |
| SAT VAP | 297.88 | 46.350 | 231.8 | .8496 | .5975 | .7994 | 151.9 |
| | 300.00 | 45.746 | 233.5 | .8552 | .6000 | .7976 | 153.1 |
| | 320.00 | 40.970 | 249.4 | .9064 | .6234 | .7909 | 162.9 |
| | 340.00 | 37.353 | 265.2 | .9544 | .6457 | .7947 | 171.3 |
| | 360.00 | 34.471 | 281.2 | 1.0001 | .6676 | .8035 | 178.7 |
| | 380.00 | 32.096 | 297.4 | [illegible] | .6883 | .8147 | 185.5 |
| | 400.00 | 30.091 | 313.8 | [illegible] | .7080 | .8273 | 191.7 |
| | 420.00 | 28.366 | 330.5 | 1.1264 | .7267 | .8403 | 197.5 |
| | 440.00 | 26.861 | 347.4 | 1.1660 | .7445 | .8535 | 202.9 |

# TABLE A.7 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-13B1 MIXTURE

DEW/BUBBLE LINES AT T = 253.1 K
COMPONENT A: R13B1 COMPONENT B: R22
MIXING COEFFICIENT, F = .0250

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 244.47 | .06409 | 8.079 | 1866.6 | 20919.0 | 7.644 | 82.920 | 80.040 | 44.150 | 95.373 | 54.834 |
| .1000 | .2090 | 282.43 | .06596 | 6.926 | 2064.2 | 20217.8 | 10.822 | 84.260 | 80.996 | 46.684 | 96.233 | 57.813 |
| .2000 | .3521 | 313.33 | .06784 | 6.191 | 2216.4 | 19727.3 | 12.656 | 83.320 | 81.998 | 48.436 | 97.182 | 59.958 |
| .3000 | .4613 | 339.18 | .06971 | 5.679 | 2326.0 | 19347.9 | 13.856 | 82.069 | 83.043 | 49.781 | 98.209 | 61.655 |
| .4000 | .5517 | 361.36 | .07158 | 5.297 | 2395.7 | 19031.6 | 14.565 | 80.740 | 84.132 | 50.898 | 99.303 | 63.093 |
| .5000 | .6313 | 380.81 | .07343 | 4.997 | 2427.5 | 18751.8 | 14.841 | 79.365 | 85.265 | 51.887 | 100.453 | 64.379 |
| .6000 | .7053 | 398.16 | .07525 | 4.755 | 2423.5 | 18492.4 | 14.703 | 77.920 | 86.440 | 52.806 | 101.648 | 65.578 |
| .7000 | .7769 | 413.79 | .07703 | 4.553 | 2385.8 | 18242.6 | 14.141 | 76.353 | 87.658 | 53.696 | 102.878 | 66.734 |
| .8000 | .8486 | 427.90 | .07877 | 4.383 | 2315.9 | 17994.6 | 13.104 | 74.582 | 88.919 | 54.586 | 104.134 | 67.878 |
| .9000 | .9224 | 440.55 | .08045 | 4.239 | 2215.5 | 17741.9 | 11.460 | 72.450 | 90.222 | 55.499 | 105.406 | 69.035 |
| 1.0000 | 1.0000 | 451.70 | .08207 | 4.118 | 2085.9 | 17479.3 | 8.505 | 69.324 | 91.568 | 56.457 | 106.685 | 70.226 |

DEW/BUBBLE LINES AT T = 263.1 K
COMPONENT A: R13B1 COMPONENT B: R22
MIXING COEFFICIENT, F = .0250

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 353.26 | .06570 | 5.696 | 2833.6 | 21296.5 | 11.363 | 81.538 | 81.200 | 45.461 | 97.571 | 57.102 |
| .1000 | .1949 | 401.52 | .06765 | 4.955 | 3040.1 | 20647.5 | 14.573 | 83.012 | 82.130 | 47.885 | 98.485 | 60.105 |
| .2000 | .3343 | 441.36 | .06962 | 4.464 | 3202.2 | 20172.2 | 16.441 | 82.273 | 83.106 | 49.638 | 99.495 | 62.381 |
| .3000 | .4436 | 475.03 | .07158 | 4.111 | 3322.5 | 19793.6 | 17.680 | 81.156 | 84.128 | 51.023 | 100.588 | 64.245 |
| .4000 | .5357 | 504.14 | .07354 | 3.844 | 3403.4 | 19471.7 | 18.430 | 79.912 | 85.194 | 52.197 | 101.751 | 65.862 |
| .5000 | .6179 | 529.75 | .07548 | 3.633 | 3447.1 | 19183.9 | 18.749 | 78.588 | 86.305 | 53.248 | 102.971 | 67.328 |
| .6000 | .6946 | 552.58 | .07739 | 3.460 | 3455.4 | 18915.6 | 18.656 | 77.170 | 87.461 | 54.231 | 104.237 | 68.706 |
| .7000 | .7691 | 573.09 | .07926 | 3.316 | 3430.2 | 18657.1 | 18.139 | 75.615 | 88.662 | 55.185 | 105.537 | 70.037 |
| .8000 | .8436 | 591.50 | .08109 | 3.195 | 3373.1 | 18401.1 | 17.150 | 73.843 | 89.908 | 56.137 | 106.857 | 71.353 |
| .9000 | .9200 | 607.87 | .08285 | 3.093 | 3285.6 | 18141.9 | 15.553 | 71.699 | 91.199 | 57.111 | 108.187 | 72.674 |
| 1.0000 | 1.0000 | 622.15 | .08454 | 3.007 | 3169.0 | 17874.4 | 12.647 | 68.540 | 92.535 | 58.127 | 109.516 | 74.022 |

## TABLE A.7 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-13B1 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 273.1 K
COMPONENT A: R13B1 COMPONENT B: R22
MIXING COEFFICIENT, F = .0250

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 495.71 | .06746 | 4.114 | 3823.7 | 21647.2 | 15.021 | 80.285 | 82.274 | 46.812 | 100.002 | 59.732 |
| .1000 | .1826 | 555.66 | .06951 | 3.622 | 4039.8 | 21040.9 | 18.262 | 81.855 | 83.174 | 49.147 | 100.995 | 62.819 |
| .2000 | .3182 | 605.80 | .07158 | 3.284 | 4212.3 | 20578.4 | 20.166 | 81.288 | 84.122 | 50.903 | 102.092 | 65.274 |
| .3000 | .4274 | 648.61 | .07366 | 3.036 | 4343.9 | 20199.7 | 21.442 | 80.292 | 85.115 | 52.330 | 103.279 | 67.352 |
| .4000 | .5209 | 685.83 | .07573 | 2.844 | 4436.7 | 19872.1 | 22.233 | 79.127 | 86.154 | 53.561 | 104.542 | 69.197 |
| .5000 | .6052 | 718.69 | .07778 | 2.691 | 4492.8 | 19575.9 | 22.596 | 77.851 | 87.240 | 54.675 | 105.866 | 70.896 |
| .6000 | .6845 | 747.99 | .07980 | 2.565 | 4514.0 | 19298.5 | 22.547 | 76.461 | 88.373 | 55.725 | 107.237 | 72.506 |
| .7000 | .7616 | 774.22 | .08178 | 2.460 | 4501.9 | 19030.9 | 22.076 | 74.917 | 89.552 | 56.746 | 108.640 | 74.066 |
| .8000 | .8388 | 797.64 | .08371 | 2.371 | 4458.2 | 18766.7 | 21.134 | 73.144 | 90.779 | 57.764 | 110.058 | 75.606 |
| .9000 | .9177 | 818.32 | .08557 | 2.297 | 4384.1 | 18500.6 | 19.585 | 70.988 | 92.054 | 58.803 | 111.476 | 77.144 |
| 1.0000 | 1.0000 | 836.16 | .08735 | 2.235 | 4280.9 | 18228.2 | 16.726 | 67.796 | 93.376 | 59.880 | 112.881 | 78.698 |

DEW/BUBBLE LINES AT T = 283.1 K
COMPONENT A: R13B1 COMPONENT B: R22
MIXING COEFFICIENT, F = .0250

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 677.94 | .06942 | 3.031 | 4839.0 | 21965.0 | 18.627 | 79.122 | 83.253 | 48.219 | 102.756 | 62.851 |
| .1000 | .1717 | 750.94 | .07159 | 2.696 | 5065.4 | 21393.3 | 21.901 | 80.756 | 84.119 | 50.482 | 103.865 | 66.100 |
| .2000 | .3036 | 812.74 | .07378 | 2.457 | 5249.2 | 20940.8 | 23.840 | 80.334 | 85.033 | 52.247 | 105.091 | 68.804 |
| .3000 | .4123 | 865.98 | .07599 | 2.278 | 5392.8 | 20560.9 | 25.156 | 79.447 | 85.993 | 53.717 | 106.419 | 71.169 |
| .4000 | .5070 | 912.54 | .07820 | 2.138 | 5498.4 | 20226.6 | 25.988 | 78.354 | 87.001 | 55.008 | 107.833 | 73.319 |
| .5000 | .5933 | 953.77 | .08039 | 2.024 | 5567.8 | 19921.4 | 26.394 | 77.123 | 88.057 | 56.190 | 109.316 | 75.331 |
| .6000 | .6749 | 990.52 | .08255 | 1.930 | 5602.7 | 19634.1 | 26.391 | 75.757 | 89.160 | 57.311 | 110.849 | 77.257 |
| .7000 | .7545 | 1023.34 | .08467 | 1.852 | 5604.7 | 19356.8 | 25.967 | 74.223 | 90.313 | 58.403 | 112.412 | 79.133 |
| .8000 | .8342 | 1052.49 | .08673 | 1.786 | 5575.1 | 19083.6 | 25.072 | 72.448 | 91.515 | 59.493 | 113.985 | 80.982 |
| .9000 | .9155 | 1078.03 | .08871 | 1.730 | 5515.0 | 18810.1 | 23.570 | 70.280 | 92.769 | 60.601 | 115.547 | 82.821 |
| 1.0000 | 1.0000 | 1099.82 | .09060 | 1.684 | 5425.8 | 18532.2 | 20.758 | 67.054 | 94.073 | 61.745 | 117.077 | 84.661 |

## TABLE A.7 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-13B1 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 293.1 K
COMPONENT A: R13B1 COMPONENT B: R22
MIXING COEFFICIENT, F = .0250

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 906.42 | .07162 | 2.271 | 5882.6 | 22243.5 | 22.194 | 78.014 | 84.124 | 49.700 | 105.972 | 66.642 |
| .1000 | .1619 | 993.76 | .07393 | 2.036 | 6120.1 | 21698.9 | 25.501 | 79.687 | 84.951 | 51.908 | 107.256 | 70.163 |
| .2000 | .2903 | 1068.53 | .07628 | 1.864 | 6316.2 | 21253.3 | 27.477 | 79.386 | 85.826 | 53.689 | 108.679 | 73.222 |
| .3000 | .3984 | 1133.48 | .07865 | 1.732 | 6473.0 | 20870.4 | 28.833 | 78.592 | 86.748 | 55.208 | 110.225 | 75.989 |
| .4000 | .4940 | 1190.60 | .08103 | 1.627 | 6592.5 | 20528.3 | 29.709 | 77.563 | 87.717 | 56.564 | 111.876 | 78.568 |
| .5000 | .5819 | 1241.31 | .08340 | 1.541 | 6676.5 | 20212.8 | 30.161 | 76.372 | 88.736 | 57.819 | 113.612 | 81.025 |
| .6000 | .6657 | 1286.51 | .08574 | 1.470 | 6726.4 | 19914.3 | 30.205 | 75.027 | 89.804 | 59.016 | 115.408 | 83.407 |
| .7000 | .7477 | 1326.77 | .08803 | 1.410 | 6743.6 | 19626.0 | 29.829 | 73.500 | 90.923 | 60.187 | 117.237 | 85.741 |
| .8000 | .8297 | 1362.35 | .09026 | 1.359 | 6729.2 | 19342.8 | 28.983 | 71.720 | 92.095 | 61.355 | 119.070 | 88.046 |
| .9000 | .9134 | 1393.26 | .09240 | 1.317 | 6684.2 | 19060.7 | 27.529 | 69.536 | 93.321 | 62.539 | 120.876 | 90.330 |
| 1.0000 | 1.0000 | 1419.36 | .09444 | 1.282 | 6609.7 | 18776.7 | 24.765 | 66.276 | 94.602 | 63.756 | 122.624 | 92.595 |

DEW/BUBBLE LINES AT T = 303.1 K
COMPONENT A: R13B1 COMPONENT B: R22
MIXING COEFFICIENT, F = .0250

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 1187.87 | .07412 | 1.724 | 6958.2 | 22475.0 | 25.733 | 76.927 | 84.871 | 51.278 | 109.866 | 71.386 |
| .1000 | .1532 | 1290.77 | .07662 | 1.556 | 7208.2 | 21950.7 | 29.076 | 78.616 | 85.654 | 53.450 | 111.424 | 75.339 |
| .2000 | .2781 | 1379.75 | .07917 | 1.429 | 7418.0 | 21508.5 | 31.092 | 78.413 | 86.482 | 55.255 | 113.161 | 78.926 |
| .3000 | .3854 | 1457.65 | .08174 | 1.330 | 7589.6 | 21120.2 | 32.492 | 77.698 | 87.356 | 56.830 | 115.061 | 82.285 |
| .4000 | .4816 | 1526.51 | .08434 | 1.250 | 7724.8 | 20768.1 | 33.415 | 76.723 | 88.281 | 58.258 | 117.103 | 85.501 |
| .5000 | .5712 | 1587.78 | .08694 | 1.184 | 7825.2 | 20440.3 | 33.915 | 75.564 | 89.254 | 59.594 | 119.264 | 88.632 |
| .6000 | .6569 | 1642.41 | .08951 | 1.129 | 7891.9 | 20128.7 | 34.010 | 74.234 | 90.277 | 60.878 | 121.511 | 91.714 |
| .7000 | .7411 | 1690.93 | .09204 | 1.082 | 7926.1 | 19827.4 | 33.686 | 72.708 | 91.354 | 62.138 | 123.807 | 94.767 |
| .8000 | .8255 | 1733.59 | .09450 | 1.043 | 7928.7 | 19532.3 | 32.891 | 70.918 | 92.487 | 63.394 | 126.106 | 97.796 |
| .9000 | .9114 | 1770.36 | .09686 | 1.010 | 7900.4 | 19240.1 | 31.489 | 68.714 | 93.677 | 64.664 | 128.360 | 100.796 |
| 1.0000 | 1.0000 | 1801.02 | .09909 | .982 | 7841.9 | 18948.4 | 28.775 | 65.418 | 94.927 | 65.962 | 130.517 | 103.748 |

## TABLE A.7 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-13B1 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 313.1 K
COMPONENT A: R13B1 COMPONENT B: R22
MIXING COEFFICIENT, F = .0250

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 1529.27 | .07703 | 1.323 | 8071.0 | 22650.7 | 29.261 | 75.827 | 85.474 | 52.982 | 114.800 | 77.527 |
| .1000 | .1453 | 1648.80 | .07976 | 1.200 | 8335.4 | 22139.9 | 32.644 | 77.510 | 86.203 | 55.136 | 116.808 | 82.170 |
| .2000 | .2668 | 1753.15 | .08256 | 1.105 | 8561.2 | 21696.9 | 34.705 | 77.382 | 86.977 | 56.978 | 119.069 | 86.577 |
| .3000 | .3732 | 1845.15 | .08541 | 1.029 | 8750.0 | 21300.0 | 36.153 | 76.730 | 87.795 | 58.619 | 121.573 | 90.861 |
| .4000 | .4699 | 1926.88 | .08831 | .967 | 8903.6 | 20934.7 | 37.128 | 75.797 | 88.661 | 60.131 | 124.301 | 95.096 |
| .5000 | .5608 | 1999.76 | .09122 | .915 | 9023.2 | 20591.5 | 37.685 | 74.660 | 89.576 | 61.562 | 127.228 | 99.330 |
| .6000 | .6484 | 2064.73 | .09412 | .871 | 9109.7 | 20263.4 | 37.837 | 73.336 | 90.542 | 62.946 | 130.311 | 103.591 |
| .7000 | .7348 | 2122.29 | .09698 | .834 | 9163.9 | 19946.0 | 37.571 | 71.801 | 91.563 | 64.309 | 133.497 | 107.882 |
| .8000 | .8214 | 2172.62 | .09976 | .803 | 9186.3 | 19635.7 | 36.835 | 69.993 | 92.643 | 65.669 | 136.715 | 112.190 |
| .9000 | .9094 | 2215.63 | .10243 | .776 | 9177.4 | 19330.4 | 35.490 | 67.761 | 93.785 | 67.040 | 139.878 | 116.476 |
| 1.0000 | 1.0000 | 2251.04 | .10495 | .755 | 9137.5 | 19028.6 | 32.830 | 64.421 | 94.992 | 68.434 | 142.890 | 120.682 |

DEW/BUBBLE LINES AT T = 323.1 K
COMPONENT A: R13B1 COMPONENT B: R22
MIXING COEFFICIENT, F = .0250

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 1937.77 | .08046 | 1.023 | 9228.6 | 22759.2 | 32.799 | 74.677 | 85.906 | 54.848 | 121.412 | 85.819 |
| .1000 | .1381 | 2074.85 | .08351 | .931 | 9510.5 | 22254.7 | 36.228 | 76.333 | 86.569 | 57.006 | 124.201 | 91.604 |
| .2000 | .2563 | 2195.59 | .08666 | .858 | 9755.6 | 21805.6 | 38.342 | 76.257 | 87.274 | 58.901 | 127.399 | 97.372 |
| .3000 | .3616 | 2302.75 | .08990 | .799 | 9965.7 | 21395.0 | 39.848 | 75.648 | 88.020 | 60.626 | 131.019 | 103.230 |
| .4000 | .4587 | 2398.37 | .09321 | .750 | 10142.0 | 21011.7 | 40.887 | 74.738 | 88.810 | 62.239 | 135.060 | 109.258 |
| .5000 | .5508 | 2483.82 | .09657 | .708 | 10285.6 | 20647.8 | 41.510 | 73.608 | 89.648 | 63.784 | 139.510 | 115.511 |
| .6000 | .6401 | 2559.99 | .09995 | .673 | 10397.0 | 20297.8 | 41.733 | 72.274 | 90.537 | 65.291 | 144.329 | 122.014 |
| .7000 | .7285 | 2627.28 | .10330 | .643 | 10476.7 | 19958.3 | 41.539 | 70.716 | 91.481 | 66.781 | 149.446 | 128.761 |
| .8000 | .8173 | 2685.79 | .10658 | .617 | 10524.4 | 19627.2 | 40.875 | 68.873 | 92.486 | 68.270 | 154.746 | 135.699 |
| .9000 | .9075 | 2735.33 | .10974 | .595 | 10540.1 | 19303.3 | 39.601 | 66.598 | 93.557 | 69.768 | 160.067 | 142.728 |
| 1.0000 | 1.0000 | 2775.53 | .11272 | .577 | 10523.4 | 18986.2 | 37.008 | 63.200 | 94.701 | 71.282 | 165.201 | 149.688 |

## TABLE A.7 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-13B1 MIXTURE (Concluded).

DEW/BUBBLE LINES AT T = 333.1 K
COMPONENT A: R13B1 COMPONENT B: R22
MIXING COEFFICIENT, F = .0250

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 2420.63 | .08464 | .794 | 10442.4 | 22785.3 | 36.377 | 73.432 | 86.126 | 56.928 | 130.922 | 97.663 |
| .1000 | .1315 | 2576.00 | .08813 | .724 | 10746.7 | 22278.4 | 39.865 | 75.037 | 86.705 | 59.117 | 135.188 | 105.480 |
| .2000 | .2464 | 2713.97 | .09178 | .667 | 11017.1 | 21815.5 | 42.046 | 74.982 | 87.318 | 61.090 | 140.235 | 113.740 |
| .3000 | .3505 | 2837.19 | .09559 | .620 | 11255.2 | 21383.6 | 43.627 | 74.390 | 87.967 | 62.923 | 146.164 | 122.619 |
| .4000 | .4477 | 2947.60 | .09954 | .580 | 11462.3 | 20973.6 | 44.749 | 73.479 | 88.654 | 64.669 | 153.077 | 132.287 |
| .5000 | .5408 | 3046.48 | .10361 | .546 | 11639.0 | 20579.3 | 45.463 | 72.328 | 89.381 | 66.363 | 161.073 | 142.901 |
| .6000 | .6318 | 3134.58 | .10777 | .516 | 11785.8 | 20196.7 | 45.783 | 70.954 | 90.154 | 68.033 | 170.220 | 154.594 |
| .7000 | .7222 | 3212.20 | .11197 | .491 | 11902.1 | 19823.5 | 45.691 | 69.341 | 90.980 | 69.696 | 180.522 | 167.444 |
| .8000 | .8132 | 3279.29 | .11613 | .469 | 11987.3 | 19458.9 | 45.132 | 67.428 | 91.866 | 71.362 | 191.875 | 181.422 |
| .9000 | .9056 | 3335.51 | .12019 | .450 | 12039.9 | 19103.6 | 43.961 | 65.074 | 92.821 | 73.038 | 204.002 | 196.343 |
| 1.0000 | 1.0000 | 3380.40 | .12404 | .435 | 12058.3 | 18759.2 | 41.467 | 61.584 | 93.855 | 74.723 | 216.408 | 211.791 |

## TABLE A.8 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-13B1 MIXTURE

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .200 MASS FRACTION R13B1
= .127 MOLE FRACTION R13B1
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 226.89 | 1507.767 | -3.8 | .0124 | .8258 | .9676 | 396.0 |
| SAT VAP | 229.96 | 5.101 | 207.0 | .9334 | .4520 | .5517 | 152.1 |
| | 240.00 | 4.868 | 212.6 | .9572 | .4649 | .5634 | 155.5 |
| | 260.00 | 4.465 | 224.1 | 1.0032 | .4899 | .5864 | 161.9 |
| | 280.00 | 4.127 | 236.0 | 1.0475 | .5140 | .6091 | 167.9 |
| | 300.00 | 3.838 | 248.4 | 1.0903 | .5373 | .6312 | 173.7 |
| | 320.00 | 3.588 | 261.3 | 1.1317 | .5597 | .6527 | 179.3 |
| | 340.00 | 3.370 | 274.5 | 1.1719 | .5812 | .6734 | 184.6 |
| | 360.00 | 3.177 | 288.2 | 1.2110 | .6019 | .6935 | 189.7 |
| | 380.00 | 3.006 | 302.2 | 1.2490 | .6217 | .7128 | 194.7 |
| | 400.00 | 2.852 | 316.7 | 1.2860 | .6407 | .7313 | 199.5 |
| | 420.00 | 2.714 | 331.5 | 1.3221 | .6588 | .7491 | 204.3 |
| | 440.00 | 2.589 | 346.6 | 1.3574 | .6761 | .7660 | 208.8 |

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .400 MASS FRACTION R13B1
= .279 MOLE FRACTION R13B1
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 223.09 | 1606.992 | -5.3 | .0165 | .7610 | .8855 | 371.0 |
| SAT VAP | 227.34 | 5.686 | 181.8 | .8465 | .4241 | .5151 | 143.6 |
| | 240.00 | 5.358 | 188.4 | .8748 | .4392 | .5287 | 147.7 |
| | 260.00 | 4.914 | 199.2 | .9179 | .4624 | .5501 | 153.8 |
| | 280.00 | 4.542 | 210.4 | .9595 | .4847 | .5710 | 159.6 |
| | 300.00 | 4.224 | 222.0 | .9996 | .5061 | .5914 | 165.2 |
| | 320 00 | 3.949 | 234.0 | 1.0384 | 5266 | .6110 | 170.5 |
| | 340.00 | 3.709 | 246.5 | 1.0760 | .5462 | .6300 | 175.6 |
| | 360.00 | 3.497 | 259.2 | 1.1125 | .5650 | .6482 | 180.5 |
| | 380.00 | 3.308 | 272.4 | 1.1480 | .5829 | .6656 | 185.2 |
| | 400.00 | 3.139 | 285.9 | 1.1826 | .5999 | .6822 | 189.9 |
| | 420.00 | 2.987 | 299.7 | 1.2163 | .6161 | .6980 | 194.4 |
| | 440.00 | 2.850 | 313.8 | 1.2491 | .6314 | .7130 | 198.7 |

## TABLE A.8 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-13B1 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .600 MASS FRACTION R13B1
= .466 MOLE FRACTION R13B1
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 220.11 | 1716.617 | -6.7 | .0119 | .6993 | .8075 | 343.4 |
| SAT VAP | 223.85 | 6.430 | 156.4 | .7469 | .3958 | .4780 | 134.6 |
| | 240.00 | 5.957 | 164.2 | .7808 | .4136 | .4941 | 139.6 |
| | 260.00 | 5.464 | 174.3 | .8211 | .4349 | .5138 | 145.4 |
| | 280.00 | 5.050 | 184.8 | .8599 | .4553 | .5330 | 150.9 |
| | 300.00 | 4.696 | 195.6 | .8973 | .4749 | .5515 | 156.2 |
| | 320.00 | 4.391 | 206.8 | .9334 | .4935 | .5694 | 161.2 |
| | 340.00 | 4.124 | 218.4 | .9685 | .5112 | .5865 | 166.1 |
| | 360.00 | 3.888 | 230.3 | 1.0025 | .5281 | .6029 | 170.7 |
| | 380.00 | 3.679 | 242.5 | 1.0355 | .5441 | .6184 | 175.3 |
| | 400.00 | 3.491 | 255.0 | 1.0676 | .5592 | .6331 | 179.7 |
| | 420.00 | 3.322 | 267.8 | 1.0988 | .5734 | .6470 | 183.9 |
| | 440.00 | 3.169 | 280.9 | 1.1292 | .5867 | .6601 | 188.1 |

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .800 MASS FRACTION R13B1
= .699 MOLE FRACTION R13B1
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 217.56 | 1842.163 | -8.7 | -.0057 | .6403 | .7327 | 314.3 |
| SAT VAP | 219.39 | 7.406 | 130.8 | .6333 | .3670 | .4407 | 124.9 |
| | 220.00 | 7.383 | 131.0 | .6346 | .3677 | .4412 | 125.1 |
| | 240.00 | 6.708 | 140.0 | .6738 | .3880 | .4596 | 131.0 |
| | 260.00 | 6.153 | 149.4 | .7113 | .4075 | .4776 | 136.5 |
| | 280.00 | 5.686 | 159.1 | .7473 | .4260 | .4950 | 141.7 |
| | 300.00 | 5.288 | 169.2 | .7820 | .4437 | .5118 | 146.7 |
| | 320.00 | 4.944 | 179.6 | .8156 | .4604 | .5278 | 151.4 |
| | 340.00 | 4.644 | 190.3 | .8480 | .4763 | .5431 | 156.0 |
| | 360.00 | 4.378 | 201.3 | .8795 | .4912 | .5576 | 160.4 |
| | 380.00 | 4.142 | 212.6 | .9100 | .5052 | .5712 | 164.7 |
| | 400.00 | 3.931 | 224.2 | .9396 | .5184 | .5841 | 168.9 |
| | 420.00 | 3.741 | 236.0 | .9684 | .5306 | .5960 | 172.9 |
| | 440.00 | 3.569 | 248.0 | .9964 | .5420 | .6071 | 176.9 |

## TABLE A.8 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-13B1 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .200 MASS FRACTION R13B1
= .127 MOLE FRACTION R13B1

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 262.16 | 1387.835 | 31.7 | .1568 | .8718 | 1.0438 | 325.3 |
| SAT VAP | 264.30 | 18.863 | 221.6 | .8778 | .5001 | .6288 | 155.3 |
| | 280.00 | 17.500 | 231.6 | .9144 | .5189 | .6404 | 161.3 |
| | 300.00 | 16.064 | 244.6 | .9591 | .5420 | .6569 | 168.4 |
| | 320.00 | 14.875 | 257.9 | 1.0021 | .5644 | .6743 | 174.9 |
| | 340.00 | 13.869 | 271.6 | 1.0435 | .5859 | .6919 | 181.0 |
| | 360.00 | 13.003 | 285.6 | 1.0836 | .6065 | .7096 | 186.8 |
| | 380.00 | 12.249 | 299.9 | 1.1224 | .6263 | .7269 | 192.3 |
| | 400.00 | 11.584 | 314.6 | 1.1601 | .6452 | .7438 | 197.5 |
| | 420.00 | 10.993 | 329.7 | 1.1968 | .6632 | .7602 | 202.5 |
| | 440.00 | 10.464 | 345.0 | 1.2325 | .6804 | .7760 | 207.4 |

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .400 MASS FRACTION R13B1
= .279 MOLE FRACTION R13B1

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 258.33 | 1478.597 | 27.2 | .1506 | .8027 | .9547 | 304.0 |
| SAT VAP | 261.34 | 21.056 | 195.4 | .7977 | .4687 | .5869 | 146.4 |
| | 280.00 | 19.245 | 206.4 | .8386 | .4893 | .5996 | 153.4 |
| | 300.00 | 17.669 | 218.6 | .8805 | .5106 | .6148 | 160.1 |
| | 320.00 | 16.363 | 231.0 | .9207 | .5310 | .6307 | 166.4 |
| | 340.00 | 15.257 | 243.8 | .9594 | .5506 | .6468 | 172.2 |
| | 360.00 | 14.306 | 256.9 | .9968 | .5693 | .6628 | 177.7 |
| | 380.00 | 13.478 | 270.3 | 1.0331 | .5872 | .6784 | 182.9 |
| | 400.00 | 12.747 | 284.0 | 1.0682 | .6041 | .6936 | 187.9 |
| | 420.00 | 12.097 | 298.0 | 1.1024 | .6202 | .7082 | 192.7 |
| | 440.00 | 11.515 | 312.3 | 1.1357 | .6354 | .7221 | 197.3 |

## TABLE A.8 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-13B1 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .600 MASS FRACTION R13B1
= .466 MOLE FRACTION R13B1
PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 255.04 | 1579.078 | 22.6 | .1346 | .7364 | .8699 | 280.7 |
| SAT VAP | 257.64 | 23.848 | 168.9 | .7053 | .4370 | .5451 | 137.0 |
| | 260.00 | 23.556 | 170.2 | .7102 | .4395 | .5464 | 137.9 |
| | 280.00 | 21.383 | 181.2 | .7512 | .4598 | .5589 | 145.0 |
| | 300.00 | 19.634 | 192.5 | .7902 | .4792 | .5728 | 151.4 |
| | 320.00 | 18.184 | 204.1 | .8276 | .4977 | .5872 | 157.3 |
| | 340.00 | 16.958 | 216.0 | .8637 | .5154 | .6018 | 162.9 |
| | 360.00 | 15.902 | 228.2 | .8985 | .5321 | .6161 | 168.1 |
| | 380.00 | 14.982 | 240.7 | .9322 | .5480 | .6300 | 173.1 |
| | 400.00 | 14.171 | 253.4 | .9648 | .5631 | .6434 | 177.8 |
| | 420.00 | 13.449 | 266.4 | .9965 | .5772 | .6561 | 182.4 |
| | 440.00 | 12.803 | 279.6 | 1.0273 | .5904 | .6682 | 186.8 |

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .800 MASS FRACTION R13B1
= .699 MOLE FRACTION R13B1
PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 252.12 | 1694.129 | 17.6 | .1057 | .6728 | .7887 | 256.2 |
| SAT VAP | 253.34 | 27.473 | 142.4 | .5997 | .4055 | .5038 | 126.9 |
| | 260.00 | 26.515 | 145.7 | .6128 | .4118 | .5070 | 129.4 |
| | 280.00 | 24.069 | 156.0 | .6507 | .4302 | .5183 | 136.1 |
| | 300.00 | 22.100 | 166.5 | .6869 | .4478 | .5309 | 142.2 |
| | 320.00 | 20.469 | 177.2 | .7216 | .4644 | .5439 | 147.8 |
| | 340.00 | 19.089 | 188.2 | .7550 | .4801 | .5568 | 153.0 |
| | 360.00 | 17.902 | 199.5 | .7872 | .4950 | .5695 | 158.0 |
| | 380.00 | 16.867 | 211.0 | .8183 | .5090 | .5816 | 162.7 |
| | 400.00 | 15.954 | 222.8 | .8484 | .5220 | .5932 | 167.2 |
| | 420.00 | 15.143 | 234.7 | .8776 | .5342 | .6042 | 171.5 |
| | 440.00 | 14.416 | 246.9 | .9060 | .5454 | .6144 | 175.6 |

## TABLE A.8 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-13B1 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .200 MASS FRACTION R13B1
= .127 MOLE FRACTION R13B1

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 279.90 | 1320.563 | 50.7 | .2260 | .8907 | 1.0934 | 291.4 |
| SAT VAP | 281.65 | 32.516 | 227.8 | .8565 | .5263 | .6854 | 154.6 |
| | 300.00 | 29.593 | 240.4 | .8999 | .5473 | .6902 | 162.6 |
| | 320.00 | 27.073 | 254.3 | .9447 | .5694 | .7005 | 170.3 |
| | 340.00 | 25.024 | 268.5 | .9876 | .5908 | .7133 | 177.3 |
| | 360.00 | 23.314 | 282.9 | 1.0287 | .6113 | .7275 | 183.8 |
| | 380.00 | 21.856 | 297.6 | 1.0685 | .6309 | .7423 | 189.8 |
| | 400.00 | 20.593 | 312.5 | 1.1069 | .6497 | .7572 | 195.4 |
| | 420.00 | 19.486 | 327.8 | 1.1442 | .6677 | .7719 | 200.8 |
| | 440.00 | 18.506 | 343.4 | 1.1804 | .6848 | .7864 | 205.9 |

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .400 MASS FRACTION R13B1
= .279 MOLE FRACTION R13B1

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 276.11 | 1406.162 | 44.6 | .2150 | .8199 | 1.0001 | 271.8 |
| SAT VAP | 278.57 | 36.341 | 201.1 | .7791 | .4930 | .6401 | 145.6 |
| | 280.00 | 36.050 | 202.0 | .7824 | .4945 | .6401 | 146.3 |
| | 300.00 | 32.521 | 214.8 | .8267 | .5155 | .6449 | 154.7 |
| | 320.00 | 29.760 | 227.8 | .8686 | .5358 | .6544 | 162.0 |
| | 340.00 | 27.515 | 241.0 | .9086 | .5552 | .6662 | 168.7 |
| | 360.00 | 25.639 | 254.5 | .9471 | .5738 | .6791 | 174.8 |
| | 380.00 | 24.040 | 268.2 | .9841 | .5915 | .6923 | 180.6 |
| | 400.00 | 22.654 | 282.2 | 1.0200 | .6084 | .7057 | 185.9 |
| | 420.00 | 21.439 | 296.4 | 1.0547 | .6244 | .7188 | 191.1 |
| | 440.00 | 20.362 | 310.9 | 1.0885 | .6395 | .7315 | 195.9 |

## TABLE A.8 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-13B1 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .600 MASS FRACTION R13B1
= .466 MOLE FRACTION R13B1

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 272.72 | 1500.822 | 38.4 | .1937 | .7515 | .9113 | 250.4 |
| SAT VAP | 274.84 | 41.216 | 174.2 | .6896 | .4596 | .5953 | 136.1 |
| | 280.00 | 40.015 | 177.2 | .7007 | .4647 | .5953 | 138.3 |
| | 300.00 | 36.111 | 189.2 | .7419 | .4838 | .5999 | 146.3 |
| | 320.00 | 33.053 | 201.3 | .7809 | .5022 | .6086 | 153.3 |
| | 340.00 | 30.566 | 213.5 | .8181 | .5197 | .6192 | 159.6 |
| | 360.00 | 28.487 | 226.0 | .8538 | .5363 | .6307 | 165.4 |
| | 380.00 | 26.713 | 238.8 | .8882 | .5521 | .6425 | 170.9 |
| | 400.00 | 25.177 | 251.7 | .9215 | .5670 | .6542 | 176.0 |
| | 420.00 | 23.829 | 264.9 | .9537 | .5811 | .6657 | 180.8 |
| | 440.00 | 22.634 | 278.4 | .9849 | .5942 | .6767 | 185.5 |

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .800 MASS FRACTION R13B1
= .699 MOLE FRACTION R13B1

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 269.67 | 1609.071 | 31.8 | .1594 | .6859 | .8262 | 227.8 |
| SAT VAP | 270.65 | 47.538 | 147.3 | .5872 | .4266 | .5513 | 125.9 |
| | 280.00 | 45.009 | 152.5 | .6059 | .4349 | .5510 | 129.8 |
| | 300.00 | 40.622 | 163.5 | .6440 | .4522 | .5552 | 137.3 |
| | 320.00 | 37.188 | 174.7 | .6801 | .4686 | .5630 | 144.0 |
| | 340.00 | 34.393 | 186.0 | .7145 | .4842 | .5725 | 149.9 |
| | 360.00 | 32.058 | 197.6 | .7475 | .4989 | .5826 | 155.5 |
| | 380.00 | 30.066 | 209.3 | .7793 | .5128 | .5928 | 160.6 |
| | 400.00 | 28.340 | 221.3 | .8099 | .5257 | .6030 | 165.4 |
| | 420.00 | 26.825 | 233.5 | .8396 | .5378 | .6127 | 170.0 |
| | 440.00 | 25.482 | 245.8 | .8683 | .5489 | .6220 | 174.4 |

**TABLE A.8 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-13B1 MIXTURE (CONTINUED)**

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .200 MASS FRACTION R13B1
= .127 MOLE FRACTION R13B1

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 292.55 | 1268.273 | 64.8 | .2745 | .9020 | 1.1381 | 267.7 |
| SAT VAP | 294.05 | 46.487 | 231.4 | .8424 | .5465 | .7397 | 153.1 |
| | 300.00 | 44.869 | 235.8 | .8571 | .5530 | .7360 | 156.2 |
| | 320.00 | 40.397 | 250.5 | .9045 | .5748 | .7332 | 165.4 |
| | 340.00 | 36.949 | 265.2 | .9491 | .5959 | .7385 | 173.5 |
| | 360.00 | 34.170 | 280.0 | .9915 | .6162 | .7477 | 180.7 |
| | 380.00 | 31.861 | 295.1 | 1.0322 | .6357 | .7590 | 187.2 |
| | 400.00 | 29.900 | 310.4 | 1.0715 | .6544 | .7714 | 193.3 |
| | 420.00 | 28.206 | 326.0 | 1.1094 | .6723 | .7843 | 199.0 |
| | 440.00 | 26.722 | 341.8 | 1.1462 | .6893 | .7972 | 204.4 |

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .400 MASS FRACTION R13B1
= .279 MOLE FRACTION R13B1

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 288.80 | 1349.644 | 57.5 | .2600 | .8301 | 1.0412 | 249.1 |
| SAT VAP | 290.91 | 52.016 | 204.4 | .7668 | .5118 | .6913 | 144.1 |
| | 300.00 | 49.246 | 210.7 | .7880 | .5210 | .6860 | 148.6 |
| | 320.00 | 44.368 | 224.4 | .8321 | .5409 | .6839 | 157.4 |
| | 340.00 | 40.600 | 238.1 | .8737 | .5600 | .6889 | 165.0 |
| | 360.00 | 37.559 | 251.9 | .9133 | .5784 | .6973 | 171.9 |
| | 380.00 | 35.031 | 266.0 | .9513 | .5960 | .7075 | 178.2 |
| | 400.00 | 32.882 | 280.2 | .9879 | .6127 | .7185 | 184.0 |
| | 420.00 | 31.025 | 294.7 | 1.0232 | .6286 | .7299 | 189.4 |
| | 440.00 | 29.397 | 309.4 | 1.0574 | .6436 | .7413 | 194.5 |

## TABLE A.8 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-13B1 MIXTURE (Concluded).

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .600 MASS FRACTION R13B1
= .466 MOLE FRACTION R13B1

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 285.38 | 1439.427 | 50.2 | .2350 | .7604 | .9492 | 229.0 |
| SAT VAP | 287.17 | 59.075 | 177.3 | .6792 | .4771 | .6440 | 134.4 |
| | 300.00 | 54.618 | 185.5 | .7072 | .4890 | .6365 | 140.6 |
| | 320.00 | 49.237 | 198.2 | .7481 | .5070 | .6349 | 148.9 |
| | 340.00 | 45.073 | 210.9 | .7867 | .5242 | .6395 | 156.2 |
| | 360.00 | 41.711 | 223.8 | .8235 | .5407 | .6471 | 162.7 |
| | 380.00 | 38.913 | 236.8 | .8587 | .5563 | .6561 | 168.6 |
| | 400.00 | 36.533 | 250.1 | .8926 | .5711 | .6658 | 174.1 |
| | 420.00 | 34.476 | 263.5 | .9254 | .5850 | .6757 | 179.3 |
| | 440.00 | 32.672 | 277.1 | .9570 | .5980 | .6855 | 184.1 |

SUPERHEATED VAPOR PROPERTIES FOR R13B1 /R22
MIXING COEFFICIENT = .025
COMPOSITION = .800 MASS FRACTION R13B1
= .699 MOLE FRACTION R13B1

PRESSURE = 1000 00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 282.26 | 1541.899 | 42.3 | .1971 | .6935 | .8611 | 207.8 |
| SAT VAP | 283.07 | 68.237 | 150.2 | .5788 | .4430 | .5980 | 124.1 |
| | 300.00 | 61.389 | 160.3 | .6132 | .4570 | .5877 | 132.0 |
| | 320.00 | 55.359 | 172.0 | .6511 | .4731 | .5865 | 139.9 |
| | 340.00 | 50.692 | 183.8 | .6867 | .4885 | .5905 | 146.7 |
| | 360.00 | 46.920 | 195.6 | .7207 | .5030 | .5972 | 152.9 |
| | 380.00 | 43.782 | 207.6 | .7531 | .5167 | .6050 | 158.5 |
| | 400.00 | 41.112 | 219.8 | .7844 | .5295 | .6133 | 163.7 |
| | 420.00 | 38.802 | 232.2 | .8145 | .5414 | .6216 | 168.5 |
| | 440.00 | 36.778 | 244.7 | .8436 | .5525 | .6298 | 173.1 |

# TABLE A.9 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-290 MIXTURE

DEW/BUBBLE LINES AT T = 263.1 K
COMPONENT A: R22 COMPONENT B: R290
MIXING COEFFICIENT, F = .0720

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 344.54 | .08142 | 5.764 | 3035.9 | 20065.4 | 12.166 | 76.892 | 92.286 | 57.708 | 105.476 | 69.920 |
| .1000 | .1705 | 380.15 | .08083 | 5.195 | 3347.9 | 20225.9 | 15.484 | 80.566 | 90.495 | 55.675 | 104.646 | 68.175 |
| .2000 | .2889 | 404.70 | .08005 | 4.861 | 3598.8 | 20337.0 | 17.436 | 81.728 | 88.823 | 54.262 | 103.850 | 66.969 |
| .3000 | .3783 | 420.80 | .07905 | 4.663 | 3784.5 | 20424.5 | 18.716 | 82.293 | 87.283 | 53.190 | 103.070 | 66.027 |
| .4000 | .4511 | 430.33 | .07781 | 4.555 | 3900.4 | 20501.4 | 19.447 | 82.634 | 85.887 | 52.311 | 102.289 | 65.208 |
| .5000 | .5150 | 434.55 | .07634 | 4.511 | 3941.5 | 20575.4 | 19.670 | 82.887 | 84.648 | 51.533 | 101.498 | 64.428 |
| .6000 | .5761 | 434.01 | .07462 | 4.523 | 3902.7 | 20653.5 | 19.384 | 83.109 | 83.577 | 50.780 | 100.690 | 63.615 |
| .7000 | .6408 | 428.41 | .07267 | 4.594 | 3778.5 | 20743.8 | 18.565 | 83.322 | 82.687 | 49.976 | 99.872 | 62.684 |
| .8000 | .7181 | 416.19 | .07051 | 4.749 | 3563.1 | 20859.4 | 17.148 | 83.509 | 81.987 | 49.008 | 99.060 | 61.503 |
| .9000 | .8246 | 393.65 | .06818 | 5.056 | 3250.4 | 21025.4 | 14.986 | 83.499 | 81.488 | 47.667 | 98.282 | 59.826 |
| 1.0000 | 1.0000 | 353.26 | .06570 | 5.696 | 2833.6 | 21296.5 | 11.363 | 81.538 | 81.200 | 45.461 | 97.571 | 57.102 |

DEW/BUBBLE LINES AT T = 273.1 K
COMPONENT A: R22 COMPONENT B: R290
MIXING COEFFICIENT, F = .0720

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 473.35 | .08345 | 4.246 | 4109.5 | 20533.1 | 16.131 | 76.268 | 94.314 | 60.173 | 108.643 | 73.786 |
| .1000 | .1656 | 520.04 | .08295 | 3.838 | 4413.1 | 20657.2 | 19.415 | 79.787 | 92.400 | 58.033 | 107.849 | 72.043 |
| .2000 | .2839 | 553.06 | .08224 | 3.591 | 4655.9 | 20745.6 | 21.335 | 80.910 | 90.608 | 56.501 | 107.082 | 70.807 |
| .3000 | .3754 | 575.34 | .08129 | 3.441 | 4833.6 | 20818.4 | 22.583 | 81.448 | 88.952 | 55.312 | 106.315 | 69.810 |
| .4000 | .4511 | 589.06 | .08008 | 3.356 | 4941.4 | 20885.9 | 23.284 | 81.762 | 87.448 | 54.318 | 105.523 | 68.911 |
| .5000 | .5184 | 595.65 | .07859 | 3.319 | 4974.2 | 20954.5 | 23.475 | 81.983 | 86.107 | 53.425 | 104.685 | 68.025 |
| .6000 | .5829 | 595.76 | .07683 | 3.323 | 4926.8 | 21029.9 | 23.159 | 82.165 | 84.943 | 52.558 | 103.794 | 67.076 |
| .7000 | .6507 | 589.02 | .07480 | 3.372 | 4793.9 | 21119.2 | 22.308 | 82.326 | 83.968 | 51.635 | 102.854 | 65.978 |
| .8000 | .7300 | 573.64 | .07254 | 3.481 | 4569.8 | 21234.1 | 20.861 | 82.435 | 83.192 | 50.545 | 101.884 | 64.594 |
| .9000 | .8355 | 545.35 | .07008 | 3.692 | 4248.5 | 21395.6 | 18.670 | 82.303 | 82.624 | 49.086 | 100.919 | 62.681 |
| 1.0000 | 1.0000 | 495.71 | .06746 | 4.114 | 3823.7 | 21647.2 | 15.021 | 80.285 | 82.274 | 46.812 | 100.002 | 59.732 |

## TABLE A.9 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-290 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 283.1 K
COMPONENT A: R22 COMPONENT B: R290
MIXING COEFFICIENT, F = .0720

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 635.04 | .08569 | 3.185 | 5215.6 | 20981.0 | 20.059 | 75.748 | 96.250 | 62.680 | 112.069 | 78.140 |
| .1000 | .1608 | 695.01 | .08531 | 2.886 | 5511.1 | 21066.6 | 23.310 | 79.105 | 94.209 | 60.448 | 111.361 | 76.460 |
| .2000 | .2789 | 738.43 | .08469 | 2.700 | 5746.1 | 21129.0 | 25.199 | 80.179 | 92.293 | 58.806 | 110.671 | 75.243 |
| .3000 | .3721 | 768.54 | .08381 | 2.584 | 5915.8 | 21183.8 | 26.417 | 80.682 | 90.520 | 57.502 | 109.961 | 74.227 |
| .4000 | .4506 | 787.74 | .08262 | 2.515 | 6015.3 | 21239.1 | 27.087 | 80.962 | 88.904 | 56.392 | 109.190 | 73.269 |
| .5000 | .5211 | 797.64 | .08113 | 2.484 | 6039.4 | 21299.9 | 27.247 | 81.145 | 87.461 | 55.382 | 108.327 | 72.282 |
| .6000 | .5888 | 798.93 | .07932 | 2.484 | 5982.7 | 21370.7 | 26.898 | 81.283 | 86.204 | 54.396 | 107.355 | 71.188 |
| .7000 | .6595 | 791.20 | .07720 | 2.518 | 5839.9 | 21457.9 | 26.014 | 81.388 | 85.144 | 53.351 | 106.278 | 69.899 |
| .8000 | .7406 | 772.39 | .07482 | 2.596 | 5605.5 | 21571.4 | 24.533 | 81.421 | 84.294 | 52.137 | 105.120 | 68.276 |
| .9000 | .8451 | 737.74 | .07220 | 2.745 | 5273.9 | 21729.0 | 22.308 | 81.180 | 83.661 | 50.560 | 103.926 | 66.080 |
| 1.0000 | 1.0000 | 677.94 | .06942 | 3.031 | 4839.1 | 21965.0 | 18.627 | 79.122 | 83.253 | 48.219 | 102.756 | 62.851 |

DEW/BUBBLE LINES AT T = 293.1 K
COMPONENT A: R22 COMPONENT B: R290
MIXING COEFFICIENT, F = .0720

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 834.29 | .08819 | 2.426 | 6356.3 | 21403.8 | 23.958 | 75.298 | 98.085 | 65.246 | 115.868 | 83.162 |
| .1000 | .1560 | 909.91 | .08795 | 2.202 | 6644.4 | 21448.2 | 27.179 | 78.486 | 95.911 | 62.939 | 115.321 | 81.633 |
| .2000 | .2737 | 965.92 | .08746 | 2.059 | 6872.1 | 21481.0 | 29.040 | 79.501 | 93.868 | 61.196 | 114.784 | 80.511 |
| .3000 | .3686 | 1005.75 | .08666 | 1.967 | 7034.3 | 21514.4 | 30.229 | 79.961 | 91.973 | 59.782 | 114.197 | 79.533 |
| .4000 | .4496 | 1031.99 | .08552 | 1.912 | 7125.7 | 21554.2 | 30.870 | 80.199 | 90.243 | 58.557 | 113.499 | 78.553 |
| .5000 | .5230 | 1046.36 | .08402 | 1.885 | 7140.8 | 21604.5 | 30.999 | 80.338 | 88.695 | 57.428 | 112.640 | 77.478 |
| .6000 | .5939 | 1049.56 | .08215 | 1.883 | 7074.1 | 21669.0 | 30.617 | 80.428 | 87.344 | 56.318 | 111.590 | 76.228 |
| .7000 | .6672 | 1041.13 | .07993 | 1.907 | 6920.2 | 21752.8 | 29.696 | 80.476 | 86.202 | 55.147 | 110.350 | 74.712 |
| .8000 | .7500 | 1018.74 | .07740 | 1.964 | 6673.8 | 21864.5 | 28.176 | 80.434 | 85.279 | 53.805 | 108.955 | 72.793 |
| .9000 | .8534 | 977.19 | .07460 | 2.071 | 6329.8 | 22019.1 | 25.912 | 80.096 | 84.584 | 52.110 | 107.468 | 70.242 |
| 1.0000 | 1.0000 | 906.42 | .07162 | 2.271 | 5882.6 | 22243.5 | 22.194 | 78.014 | 84.124 | 49.700 | 105.972 | 66.642 |

## TABLE A.9 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-290 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 303.1 K
COMPONENT A: R22 COMPONENT B: R290
MIXING COEFFICIENT, F = .0720

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 1075.85 | .09102 | 1.871 | 7534.5 | 21795.3 | 27.838 | 74.888 | 99.805 | 67.890 | 120.223 | 89.118 |
| .1000 | .1514 | 1169.68 | .09097 | 1.700 | 7816.4 | 21795.4 | 31.033 | 77.900 | 97.494 | 65.527 | 119.952 | 87.874 |
| .2000 | .2684 | 1240.69 | .09064 | 1.588 | 8037.9 | 21794.7 | 32.868 | 78.844 | 95.317 | 63.696 | 119.686 | 86.968 |
| .3000 | .3646 | 1292.42 | .08996 | 1.515 | 8193.6 | 21802.4 | 34.034 | 79.251 | 93.294 | 62.178 | 119.332 | 86.127 |
| .4000 | .4480 | 1327.55 | .08888 | 1.469 | 8277.6 | 21823.2 | 34.648 | 79.439 | 91.446 | 60.839 | 118.794 | 85.193 |
| .5000 | .5243 | 1347.80 | .08738 | 1.446 | 8283.7 | 21860.1 | 34.746 | 79.529 | 89.790 | 59.590 | 117.988 | 84.058 |
| .6000 | .5981 | 1353.86 | .08545 | 1.443 | 8206.2 | 21916.1 | 34.329 | 79.566 | 88.344 | 58.354 | 116.863 | 82.637 |
| .7000 | .6740 | 1345.18 | .08310 | 1.460 | 8039.8 | 21995.5 | 33.369 | 79.555 | 87.121 | 57.051 | 115.416 | 80.839 |
| .8000 | .7583 | 1319.19 | .08038 | 1.502 | 7779.4 | 22105.5 | 31.805 | 79.442 | 86.130 | 55.577 | 113.700 | 78.530 |
| .9000 | .8607 | 1270.31 | .07736 | 1.581 | 7420.5 | 22258.4 | 29.496 | 79.019 | 85.379 | 53.760 | 111.810 | 75.500 |
| 1.0000 | 1.0000 | 1187.87 | .07412 | 1.724 | 6958.2 | 22475.0 | 25.733 | 76.927 | 84.871 | 51.278 | 109.866 | 71.386 |

DEW/BUBBLE LINES AT T = 313.1 K
COMPONENT A: R22 COMPONENT B: R290
MIXING COEFFICIENT, F = .0720

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 1364.57 | .09428 | 1.457 | 8754.1 | 22148.2 | 31.710 | 74.489 | 101.397 | 70.636 | 125.429 | 96.424 |
| .1000 | .1466 | 1479.29 | .09447 | 1.325 | 9031.8 | 22100.2 | 34.884 | 77.314 | 98.939 | 68.239 | 125.630 | 95.682 |
| .2000 | .2628 | 1567.93 | .09435 | 1.236 | 9249.2 | 22061.2 | 36.702 | 78.175 | 96.619 | 66.336 | 125.836 | 95.202 |
| .3000 | .3601 | 1634.03 | .09383 | 1.176 | 9400.2 | 22038.4 | 37.848 | 78.517 | 94.461 | 64.724 | 125.907 | 94.679 |
| .4000 | .4458 | 1680.19 | .09285 | 1.138 | 9477.8 | 22035.8 | 38.439 | 78.647 | 92.487 | 63.276 | 125.682 | 93.917 |
| .5000 | .5249 | 1708.06 | .09137 | 1.118 | 9475.4 | 22055.9 | 38.510 | 78.680 | 90.720 | 61.906 | 125.016 | 92.782 |
| .6000 | .6015 | 1718.22 | .08935 | 1.114 | 9386.7 | 22101.2 | 38.057 | 78.661 | 89.179 | 60.539 | 123.818 | 91.171 |
| .7000 | .6800 | 1709.94 | .08684 | 1.126 | 9206.1 | 22175.3 | 37.054 | 78.590 | 87.876 | 59.100 | 122.080 | 88.992 |
| .8000 | .7657 | 1680.48 | .08388 | 1.159 | 8929.2 | 22284.1 | 35.441 | 78.411 | 86.821 | 57.487 | 119.889 | 86.126 |
| .9000 | .8672 | 1623.94 | .08058 | 1.218 | 8552.0 | 22437.4 | 33.078 | 77.914 | 86.021 | 55.543 | 117.399 | 82.401 |
| 1.0000 | 1.0000 | 1529.27 | .07703 | 1.323 | 8071.0 | 22650.7 | 29.261 | 75.827 | 85.474 | 52.982 | 114.800 | 77.527 |

## TABLE A.9 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-290 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 323.1 K
COMPONENT A: R22 COMPONENT B: R290
MIXING COEFFICIENT, F = .0720

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 1705.26 | .09811 | 1.143 | 10020.9 | 22453.8 | 35.589 | 74.069 | 102.838 | 73.516 | 132.004 | 105.772 |
| .1000 | .1418 | 1843.68 | .09862 | 1.039 | 10297.6 | 22352.7 | 38.753 | 76.694 | 100.220 | 71.111 | 133.020 | 105.915 |
| .2000 | .2568 | 1952.81 | .09879 | .967 | 10514.2 | 22269.4 | 40.561 | 77.455 | 97.745 | 69.157 | 134.075 | 106.250 |
| .3000 | .3550 | 2036.02 | .09851 | .917 | 10663.4 | 22210.0 | 41.697 | 77.720 | 95.440 | 67.465 | 134.936 | 106.396 |
| .4000 | .4428 | 2095.72 | .09768 | .885 | 10737.1 | 22178.4 | 42.274 | 77.779 | 93.332 | 65.917 | 135.325 | 106.072 |
| .5000 | .5246 | 2133.28 | .09623 | .867 | 10727.3 | 22177.4 | 42.320 | 77.747 | 91.448 | 64.427 | 134.974 | 105.069 |
| .6000 | .6042 | 2149.06 | .09412 | .863 | 10626.9 | 22209.5 | 41.831 | 77.667 | 89.808 | 62.925 | 133.705 | 103.241 |
| .7000 | .6851 | 2142.08 | .09139 | .873 | 10430.2 | 22277.9 | 40.781 | 77.537 | 88.429 | 61.341 | 131.502 | 100.490 |
| .8000 | .7723 | 2109.45 | .08812 | .898 | 10133.3 | 22386.8 | 39.110 | 77.298 | 87.319 | 59.580 | 128.525 | 96.742 |
| .9000 | .8730 | 2045.09 | .08443 | .944 | 9733.4 | 22543.6 | 36.683 | 76.743 | 86.479 | 57.500 | 125.054 | 91.905 |
| 1.0000 | 1.0000 | 1937.77 | .08046 | 1.023 | 9228.6 | 22759.2 | 32.799 | 74.677 | 85.906 | 54.848 | 121.412 | 85.819 |

DEW/BUBBLE LINES AT T = 333.1 K
COMPONENT A: R22 COMPONENT B: R290
MIXING COEFFICIENT, F = .0720

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 2102.72 | .10270 | .900 | 11343.5 | 22700.3 | 39.499 | 73.593 | 104.098 | 76.569 | 140.919 | 118.403 |
| .1000 | .1368 | 2267.69 | .10367 | .817 | 11624.5 | 22539.3 | 42.666 | 75.997 | 101.302 | 74.193 | 143.430 | 120.179 |
| .2000 | .2504 | 2400.33 | .10428 | .758 | 11845.9 | 22403.3 | 44.482 | 76.638 | 98.653 | 72.217 | 146.109 | 122.138 |
| .3000 | .3493 | 2503.71 | .10436 | .716 | 11998.8 | 22298.7 | 45.622 | 76.806 | 96.182 | 70.469 | 148.558 | 123.735 |
| .4000 | .4390 | 2579.82 | .10377 | .689 | 12072.9 | 22230.6 | 46.196 | 76.779 | 93.924 | 68.833 | 150.243 | 124.474 |
| .5000 | .5235 | 2629.57 | .10239 | .673 | 12058.1 | 22202.9 | 46.225 | 76.670 | 91.912 | 67.227 | 150.607 | 123.939 |
| .6000 | .6060 | 2652.85 | .10017 | .669 | 11945.9 | 22219.0 | 45.702 | 76.524 | 90.172 | 65.586 | 149.265 | 121.848 |
| .7000 | .6896 | 2648.36 | .09714 | .677 | 11730.1 | 22281.7 | 44.597 | 76.337 | 88.722 | 63.845 | 146.181 | 118.094 |
| .8000 | .7782 | 2613.06 | .09341 | .697 | 11407.8 | 22393.9 | 42.855 | 76.049 | 87.568 | 61.921 | 141.704 | 112.729 |
| .9000 | .8782 | 2540.86 | .08918 | .733 | 10978.5 | 22559.7 | 40.346 | 75.456 | 86.706 | 39.688 | 136.416 | 105.882 |
| 1.0000 | 1.0000 | 2420.63 | .08464 | .794 | 10442.4 | 22785.3 | 36.377 | 73.432 | 86.126 | 56.928 | 130.922 | 97.663 |

## TABLE A.9 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-290 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 343.1 K
COMPONENT A: R22  COMPONENT B: R290
MIXING COEFFICIENT, F = .0720

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 2561.64 | .10840 | .710 | 12735.5 | 22870.8 | 43.472 | 73.013 | 105.129 | 79.856 | 154.212 | 136.817 |
| .1000 | .1315 | 2755.97 | .11008 | .642 | 13030.2 | 22639.1 | 46.669 | 75.165 | 102.125 | 77.557 | 159.763 | 141.907 |
| .2000 | .2432 | 2915.26 | .11137 | .592 | 13266.7 | 22437.8 | 48.519 | 75.654 | 99.269 | 75.607 | 165.966 | 147.474 |
| .3000 | .3424 | 3042.15 | .11206 | .557 | 13433.5 | 22274.8 | 49.693 | 75.693 | 96.601 | 73.840 | 172.099 | 152.608 |
| .4000 | .4340 | 3137.98 | .11190 | .533 | 13516.7 | 22158.0 | 50.288 | 75.553 | 94.165 | 72.143 | 176.993 | 156.222 |
| .5000 | .5214 | 3202.90 | .11069 | .519 | 13502.3 | 22094.9 | 50.316 | 75.350 | 92.008 | 70.432 | 179.249 | 157.206 |
| .6000 | .6070 | 3236.02 | .10832 | .515 | 13378.5 | 22091.4 | 49.759 | 75.131 | 90.164 | 68.645 | 177.813 | 154.770 |
| .7000 | .6933 | 3235.56 | .10481 | .521 | 13138.4 | 22150.7 | 48.586 | 74.896 | 88.654 | 66.727 | 172.605 | 148.773 |
| .8000 | .7836 | 3198.32 | .10038 | .538 | 12781.4 | 22273.1 | 46.750 | 74.579 | 87.479 | 64.612 | 164.603 | 139.740 |
| .9000 | .8829 | 3118.44 | .09532 | .568 | 12310.8 | 22458.4 | 44.129 | 73.979 | 86.625 | 62.196 | 155.288 | 128.542 |
| 1.0000 | 1.0000 | 2985.21 | .08992 | .616 | 11731.2 | 22706.6 | 40.043 | 72.032 | 86.070 | 59.297 | 145.976 | 115.992 |

DEW/BUBBLE LINES AT T = 353.1 K
COMPONENT A: R22  COMPONENT B: R290
MIXING COEFFICIENT, F = .0720

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 3086.56 | .11586 | .557 | 14221.5 | 22937.9 | 47.572 | 72.257 | 105.851 | 83.468 | 176.933 | 166.955 |
| .1000 | .1257 | 3312.79 | .11870 | .501 | 14548.0 | 22616.4 | 50.846 | 74.102 | 102.584 | 81.329 | 189.897 | 180.076 |
| .2000 | .2349 | 3501.83 | .12123 | .458 | 14821.1 | 22326.0 | 52.788 | 74.376 | 99.457 | 79.489 | 205.714 | 195.615 |
| .3000 | .3340 | 3655.78 | .12311 | .427 | 15024.9 | 22078.5 | 54.057 | 74.223 | 96.523 | 77.781 | 223.211 | 212.003 |
| .4000 | .4273 | 3775.17 | .12389 | .405 | 15138.4 | 21888.6 | 54.730 | 73.913 | 93.849 | 76.083 | 239.251 | 226.175 |
| .5000 | .5176 | 3858.92 | .12312 | .392 | 15137.8 | 21773.1 | 54.793 | 73.576 | 91.505 | 74.296 | 248.744 | 233.690 |
| .6000 | .6068 | 3904.88 | .12052 | .388 | 15003.3 | 21745.3 | 54.206 | 73.277 | 89.552 | 72.353 | 247.102 | 230.729 |
| .7000 | .6963 | 3910.38 | .11613 | .394 | 14726.8 | 21809.9 | 52.935 | 73.018 | 88.012 | 70.214 | 234.069 | 216.955 |
| .8000 | .7885 | 3872.16 | .11037 | .409 | 14313.3 | 21961.6 | 50.946 | 72.725 | 86.873 | 67.843 | 214.130 | 195.837 |
| .9000 | .8873 | 3784.92 | .10381 | .436 | 13776.2 | 22189.9 | 48.148 | 72.183 | 86.094 | 65.177 | 192.767 | 171.885 |
| 1.0000 | 1.0000 | 3638.86 | .09698 | .475 | 13129.0 | 22484.9 | 43.883 | 70.379 | 85.629 | 62.077 | 173.469 | 148.238 |

**TABLE A.9 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-290 MIXTURE (Concluded).**

DEW/BUBBLE LINES AT T = 363.1 K
COMPONENT A: R22     COMPONENT B: R290
MIXING COEFFICIENT, F = .0720

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 3681.73 | .12642 | .431 | 15852.4 | 22847.6 | 51.924 | 71.190 | 106.101 | 87.583 | 225.614 | 227.515 |
| .1000 | .1190 | 3941.72 | .13164 | .383 | 16254.6 | 22392.0 | 55.392 | 72.598 | 102.443 | 85.769 | 264.604 | 268.530 |
| .2000 | .2244 | 4163.00 | .13708 | .344 | 16624.3 | 21951.0 | 57.585 | 72.493 | 98.875 | 84.246 | 323.974 | 329.342 |
| .3000 | .3223 | 4347.43 | .14229 | .313 | 16942.6 | 21539.5 | 59.155 | 71.943 | 95.460 | 82.841 | 412.617 | 417.303 |
| .4000 | .4167 | 4494.77 | .14631 | .290 | 17171.2 | 21188.6 | 60.134 | 71.240 | 92.314 | 81.382 | 530.350 | 530.807 |
| .5000 | .5105 | 4602.25 | .14755 | .277 | 17247.4 | 20953.7 | 60.402 | 70.605 | 89.612 | 79.671 | 633.568 | 628.106 |
| .6000 | .6046 | 4665.30 | .14447 | .274 | 17105.1 | 20893.8 | 59.792 | 70.211 | 87.538 | 77.544 | 630.727 | 624.811 |
| .7000 | .6987 | 4679.32 | .13721 | .281 | 16731.9 | 21020.0 | 58.260 | 70.079 | 86.127 | 74.989 | 519.297 | 515.798 |
| .8000 | .7934 | 4641.37 | .12755 | .299 | 16174.7 | 21283.9 | 55.887 | 70.028 | 85.257 | 72.116 | 393.049 | 388.983 |
| .9000 | .8917 | 4547.26 | .11729 | .324 | 15489.7 | 21635.3 | 52.696 | 69.760 | 84.773 | 68.981 | 299.813 | 290.004 |
| 1.0000 | 1.0000 | 4388.87 | .10741 | .360 | 14710.8 | 22041.6 | 48.085 | 68.275 | 84.574 | 65.514 | 238.363 | 220.622 |

## TABLE A.10 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-290 MIXTURE

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .200 MASS FRACTION R22
= .113 MOLE FRACTION R22
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 227.80 | 655.918 | -2.8 | .0313 | 1.6966 | 1.9354 | 523.0 |
| SAT VAP | 229.11 | 2.666 | 379.5 | 1.7041 | .9929 | 1.1888 | 207.8 |
| | 240.00 | 2.532 | 392.7 | 1.7604 | 1.0417 | 1.2346 | 212.7 |
| | 260.00 | 2.321 | 418.3 | 1.8625 | 1.1293 | 1.3180 | 221.3 |
| | 280.00 | 2.143 | 445.4 | 1.9632 | 1.2145 | 1.3999 | 229.5 |
| | 300.00 | 1.992 | 474.2 | 2.0625 | 1.2973 | 1.4800 | 237.4 |
| | 320.00 | 1.862 | 504.6 | 2.1605 | 1.3775 | 1.5582 | 244.9 |
| | 340.00 | 1.748 | 536.6 | 2.2573 | 1.4553 | 1.6344 | 252.1 |
| | 360.00 | 1.648 | 570.0 | 2.3528 | 1.5307 | 1.7083 | 259.1 |
| | 380.00 | 1.559 | 604.9 | 2.4471 | 1.6035 | 1.7800 | 265.9 |
| | 400.00 | 1.479 | 641.2 | 2.5402 | 1.6739 | 1.8494 | 272.5 |
| | 420.00 | 1.407 | 678.8 | 2.6321 | 1.7418 | 1.9165 | 279.0 |
| | 440.00 | 1.342 | 717.8 | 2.7227 | 1.8072 | 1.9813 | 285.2 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .400 MASS FRACTION R22
= .254 MOLE FRACTION R22
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 226.05 | 752.842 | 1.1 | .0616 | 1.4743 | 1.6999 | 495.0 |
| SAT VAP | 227.21 | 3.015 | 340.3 | 1.5586 | .8564 | 1.0307 | 196.0 |
| | 240.00 | 2.838 | 353.8 | 1.6163 | .9038 | 1.0751 | 201.4 |
| | 260.00 | 2.601 | 376.0 | 1.7051 | .9763 | 1.1438 | 209.6 |
| | 280.00 | 2.403 | 399.5 | 1.7923 | 1.0467 | 1.2114 | 217.3 |
| | 300.00 | 2.234 | 424.4 | 1.8782 | 1.1150 | 1.2775 | 224.7 |
| | 320.00 | 2.088 | 450.6 | 1.9627 | 1.1813 | 1.3421 | 231.8 |
| | 340.00 | 1.960 | 478.1 | 2.0459 | 1.2455 | 1.4048 | 238.7 |
| | 360.00 | 1.848 | 506.8 | 2.1280 | 1.3077 | 1.4658 | 245.3 |
| | 380.00 | 1.748 | 536.7 | 2.2088 | 1.3678 | 1.5249 | 251.7 |
| | 400.00 | 1.659 | 567.8 | 2.2885 | 1.4258 | 1.5821 | 257.9 |
| | 420.00 | 1.578 | 600.0 | 2.3670 | 1.4817 | 1.6373 | 264.0 |
| | 440.00 | 1.505 | 633.3 | 2.4444 | 1.5356 | 1.6906 | 269.9 |

## TABLE A.10 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-290 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .600 MASS FRACTION R22
= .433 MOLE FRACTION R22
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 225.30 | 886.196 | 4.1 | .0744 | 1.2633 | 1.4730 | 466.3 |
| SAT VAP | 225.42 | 3.458 | 301.7 | 1.3954 | .7232 | .8759 | 183.6 |
| | 240.00 | 3.227 | 314.8 | 1.4515 | .7660 | .9157 | 189.5 |
| | 260.00 | 2.959 | 333.7 | 1.5270 | .8233 | .9699 | 197.1 |
| | 280.00 | 2.734 | 353.6 | 1.6008 | .8789 | 1.0231 | 204.4 |
| | 300.00 | 2.542 | 374.6 | 1.6732 | .9328 | 1.0752 | 211.3 |
| | 320.00 | 2.376 | 396.6 | 1.7442 | .9851 | 1.1260 | 218.0 |
| | 340.00 | 2.231 | 419.6 | 1.8139 | 1.0357 | 1.1754 | 224.4 |
| | 360.00 | 2.104 | 443.6 | 1.8825 | 1.0847 | 1.2233 | 230.6 |
| | 380.00 | 1.990 | 468.5 | 1.9499 | 1.1320 | 1.2698 | 236.6 |
| | 400.00 | 1.888 | 494.4 | 2.0162 | 1.1777 | 1.3148 | 242.5 |
| | 420.00 | 1.797 | 521.1 | 2.0814 | 1.2216 | 1.3582 | 248.2 |
| | 440.00 | 1.714 | 548.7 | 2.1455 | 1.2640 | 1.4000 | 253.7 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .800 MASS FRACTION R22
= .671 MOLE FRACTION R22
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 225.64 | 1086.298 | 3.4 | .0592 | 1.0654 | 1.2542 | 440.8 |
| SAT VAP | 226.78 | 3.984 | 266.0 | 1.2208 | .5997 | .7304 | 171.7 |
| | 240.00 | 3.744 | 275.8 | 1.2629 | .6282 | .7567 | 176.7 |
| | 260.00 | 3.433 | 291.3 | 1.3251 | .6703 | .7961 | 183.8 |
| | 280.00 | 3.173 | 307.6 | 1.3855 | .7111 | .8350 | 190.6 |
| | 300.00 | 2.950 | 324.7 | 1.4444 | .7506 | .8730 | 197.1 |
| | 320.00 | 2.758 | 342.5 | 1.5019 | .7889 | .9100 | 203.3 |
| | 340.00 | 2.590 | 361.1 | 1.5582 | .8260 | .9461 | 209.3 |
| | 360.00 | 2.442 | 380.4 | 1.6133 | .8617 | .9810 | 215.1 |
| | 380.00 | 2.310 | 400.3 | 1.6672 | .8963 | 1.0148 | 220.7 |
| | 400.00 | 2.192 | 421.0 | 1.7201 | .9296 | 1.0475 | 226.1 |
| | 420.00 | 2.086 | 442.2 | 1.7720 | .9616 | 1.0791 | 231.4 |
| | 440.00 | 1.990 | 464.1 | 1.8229 | .9924 | 1.1094 | 236.6 |

## TABLE A.10 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-290 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .200 MASS FRACTION R22
= .113 MOLE FRACTION R22

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 264.37 | 603.618 | 71.9 | .3331 | 1.8513 | 2.1462 | 425.5 |
| SAT VAP | 265.66 | 9.850 | 415.0 | 1.6272 | 1.1650 | 1.4256 | 210.3 |
| | 280.00 | 9.176 | 435.7 | 1.7033 | 1.2255 | 1.4707 | 218.1 |
| | 300.00 | 8.401 | 465.8 | 1.8070 | 1.3079 | 1.5375 | 228.1 |
| | 320.00 | 7.764 | 497.2 | 1.9084 | 1.3879 | 1.6061 | 237.3 |
| | 340.00 | 7.228 | 530.1 | 2.0079 | 1.4655 | 1.6751 | 245.9 |
| | 360.00 | 6.770 | 564.2 | 2.1055 | 1.5406 | 1.7435 | 253.9 |
| | 380.00 | 6.372 | 599.8 | 2.2016 | 1.6132 | 1.8107 | 261.6 |
| | 400.00 | 6.022 | 636.7 | 2.2962 | 1.6834 | 1.8765 | 268.8 |
| | 420.00 | 5.712 | 674.8 | 2.3893 | 1.7511 | 1.9406 | 275.8 |
| | 440.00 | 5.435 | 714.3 | 2.4810 | 1.8163 | 2.0028 | 282.5 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .400 MASS FRACTION R22
= .254 MOLE FRACTION R22

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 262.03 | 691.583 | 65.6 | .3241 | 1.6005 | 1.8796 | 403.4 |
| SAT VAP | 263.28 | 11.139 | 370.3 | 1.4845 | .9977 | 1.2287 | 198.5 |
| | 280.00 | 10.258 | 391.2 | 1.5615 | 1.0561 | 1.2717 | 207.1 |
| | 300.00 | 9.398 | 417.2 | 1.6511 | 1.1242 | 1.3266 | 216.5 |
| | 320.00 | 8.691 | 444.3 | 1.7385 | 1.1902 | 1.3831 | 225.1 |
| | 340.00 | 8.095 | 472.5 | 1.8240 | 1.2542 | 1.4398 | 233.1 |
| | 360.00 | 7.584 | 501.9 | 1.9079 | 1.3162 | 1.4960 | 240.6 |
| | 380.00 | 7.140 | 532.3 | 1.9903 | 1.3761 | 1.5513 | 247.8 |
| | 400.00 | 6.750 | 563.9 | 2.0712 | 1.4340 | 1.6054 | 254.6 |
| | 420.00 | 6.403 | 596.5 | 2.1508 | 1.4898 | 1.6581 | 261.2 |
| | 440.00 | 6.093 | 630.2 | 2.2292 | 1.5435 | 1.7092 | 267.5 |

## TABLE A.10 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-290 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .600 MASS FRACTION R22
= .433 MOLE FRACTION R22

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 260.75 | 812.840 | 59.0 | .2989 | 1.3621 | 1.6220 | 380.8 |
| SAT VAP | 261.02 | 12.777 | 326.6 | 1.3248 | .8342 | 1.0358 | 186.3 |
| | 280.00 | 11.640 | 346.6 | 1.3988 | .8867 | 1.0736 | 195.4 |
| | 300.00 | 10.673 | 368.5 | 1.4743 | .9405 | 1.1164 | 204.0 |
| | 320.00 | 9.876 | 391.2 | 1.5477 | .9926 | 1.1605 | 212.0 |
| | 340.00 | 9.202 | 414.9 | 1.6194 | 1.0431 | 1.2049 | 219.5 |
| | 360.00 | 8.624 | 439.4 | 1.6895 | 1.0919 | 1.2489 | 226.5 |
| | 380.00 | 8.121 | 464.8 | 1.7582 | 1.1391 | 1.2922 | 233.2 |
| | 400.00 | 7.679 | 491.1 | 1.8256 | 1.1846 | 1.3345 | 239.6 |
| | 420.00 | 7.285 | 518.2 | 1.8917 | 1.2285 | 1.3758 | 245.7 |
| | 440.00 | 6.933 | 546.1 | 1.9566 | 1.2707 | 1.4158 | 251.6 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .800 MASS FRACTION R22
= .671 MOLE FRACTION R22

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 260.89 | 996.196 | 49.7 | .2485 | 1.1391 | 1.3716 | 360.9 |
| SAT VAP | 261.36 | 14.751 | 285.7 | 1.1526 | .6797 | .8505 | 174.5 |
| | 280.00 | 13.475 | 301.8 | 1.2120 | .7175 | .8766 | 182.7 |
| | 300.00 | 12.365 | 319.6 | 1.2735 | .7569 | .9071 | 190.7 |
| | 320.00 | 11.446 | 338.1 | 1.3331 | .7951 | .9386 | 198.1 |
| | 340.00 | 10.670 | 357.2 | 1.3909 | .8320 | .9705 | 205.0 |
| | 360.00 | 10.002 | 376.9 | 1.4473 | .8677 | 1.0022 | 211.5 |
| | 380.00 | 9.421 | 397.3 | 1.5023 | .9022 | 1.0335 | 217.7 |
| | 400.00 | 8.908 | 418.2 | 1.5561 | .9354 | 1.0640 | 223.6 |
| | 420.00 | 8.453 | 439.8 | 1.6088 | .9673 | 1.0938 | 229.3 |
| | 440.00 | 8.045 | 462.0 | 1.6603 | .9980 | 1.1226 | 234.8 |

## TABLE A.10 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-290 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .200 MASS FRACTION R22
= .113 MOLE FRACTION R22

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 283.02 | 573.706 | 113.2 | .4822 | 1.9213 | 2.2753 | 377.9 |
| SAT VAP | 284.29 | 17.013 | 431.4 | 1.6035 | 1.2558 | 1.5854 | 207.9 |
| | 300.00 | 15.627 | 456.5 | 1.6895 | 1.3197 | 1.6156 | 217.9 |
| | 320.00 | 14.232 | 489.3 | 1.7953 | 1.3991 | 1.6662 | 229.2 |
| | 340.00 | 13.115 | 523.2 | 1.8980 | 1.4762 | 1.7233 | 239.3 |
| | 360.00 | 12.192 | 558.3 | 1.9982 | 1.5509 | 1.7834 | 248.5 |
| | 380.00 | 11.410 | 594.5 | 2.0963 | 1.6232 | 1.8446 | 257.1 |
| | 400.00 | 10.738 | 632.0 | 2.1925 | 1.6931 | 1.9058 | 265.1 |
| | 420.00 | 10.150 | 670.8 | 2.2869 | 1.7606 | 1.9662 | 272.6 |
| | 440.00 | 9.632 | 710.7 | 2.3798 | 1.8256 | 2.0254 | 279.8 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .400 MASS FRACTION R22
= .254 MOLE FRACTION R22

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 280.36 | 656.575 | 101.1 | .4535 | 1.6570 | 1.9919 | 358.8 |
| SAT VAP | 281.64 | 19.238 | 383.9 | 1.4602 | 1.0724 | 1.3641 | 196.4 |
| | 300.00 | 17.432 | 409.2 | 1.5472 | 1.1342 | 1.3923 | 207.4 |
| | 320.00 | 15.898 | 437.5 | 1.6383 | 1.1998 | 1.4339 | 217.8 |
| | 340.00 | 14.664 | 466.6 | 1.7266 | 1.2634 | 1.4808 | 227.2 |
| | 360.00 | 13.640 | 496.7 | 1.8127 | 1.3251 | 1.5301 | 235.8 |
| | 380.00 | 12.773 | 527.8 | 1.8967 | 1.3848 | 1.5803 | 243.8 |
| | 400.00 | 12.024 | 559.9 | 1.9791 | 1.4424 | 1.6305 | 251.3 |
| | 420.00 | 11.370 | 593.1 | 2.0598 | 1.4980 | 1.6801 | 258.3 |
| | 440.00 | 10.792 | 627.1 | 2.1391 | 1.5515 | 1.7286 | 265.1 |

## TABLE A.10 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-290 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .600 MASS FRACTION R22
= .433 MOLE FRACTION R22

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 278.76 | 771.007 | 89.1 | .4091 | 1.4056 | 1.7171 | 339.2 |
| SAT VAP | 279.10 | 22.065 | 337.6 | 1.3002 | .8932 | 1.1471 | 184.5 |
| | 280.00 | 21.950 | 338.6 | 1.3039 | .8956 | 1.1478 | 185.0 |
| | 300.00 | 19.740 | 361.8 | 1.3838 | .9489 | 1.1708 | 196.0 |
| | 320.00 | 18.027 | 385.5 | 1.4603 | 1.0006 | 1.2029 | 205.7 |
| | 340.00 | 16.643 | 409.9 | 1.5343 | 1.0508 | 1.2392 | 214.3 |
| | 360.00 | 15.491 | 435.1 | 1.6063 | 1.0994 | 1.2776 | 222.3 |
| | 380.00 | 14.513 | 461.0 | 1.6764 | 1.1464 | 1.3166 | 229.7 |
| | 400.00 | 13.668 | 487.8 | 1.7449 | 1.1918 | 1.3557 | 236.6 |
| | 420.00 | 12.928 | 515.3 | 1.8120 | 1.2355 | 1.3944 | 243.2 |
| | 440.00 | 12.273 | 543.5 | 1.8777 | 1.2776 | 1.4322 | 249.5 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .800 MASS FRACTION R22
= .671 MOLE FRACTION R22

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 278.71 | 945.161 | 74.8 | .3406 | 1.1707 | 1.4478 | 322.2 |
| SAT VAP | 278.99 | 25.472 | 294.3 | 1.1276 | .7227 | .9364 | 173.2 |
| | 280.00 | 25.325 | 295.2 | 1.1310 | .7247 | .9368 | 173.7 |
| | 300.00 | 22.814 | 314.1 | 1.1961 | .7638 | .9516 | 183.7 |
| | 320.00 | 20.857 | 333.3 | 1.2582 | .8017 | .9735 | 192.6 |
| | 340.00 | 19.270 | 353.0 | 1.3180 | .8384 | .9989 | 200.5 |
| | 360.00 | 17.947 | 373.3 | 1.3758 | .8740 | 1.0260 | 207.8 |
| | 380.00 | 16.820 | 394.1 | 1.4320 | .9083 | 1.0538 | 214.7 |
| | 400.00 | 15.845 | 415.4 | 1.4868 | .9413 | 1.0817 | 221.1 |
| | 420.00 | 14.991 | 437.4 | 1.5403 | .9732 | 1.1093 | 227.2 |
| | 440.00 | 14.234 | 459.8 | 1.5925 | 1.0037 | 1.1364 | 233.0 |

## TABLE A.10 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-290 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .200 MASS FRACTION R22
= .113 MOLE FRACTION R22

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 296.42 | 550.153 | 144.4 | .5880 | 1.9670 | 2.3871 | 344.2 |
| SAT VAP | 297.65 | 24.387 | 441.9 | 1.5893 | 1.3238 | 1.7321 | 204.4 |
| | 300.00 | 24.021 | 446.0 | 1.6028 | 1.3331 | 1.7309 | 206.2 |
| | 320.00 | 21.431 | 480.7 | 1.7148 | 1.4113 | 1.7446 | 220.3 |
| | 340.00 | 19.492 | 515.9 | 1.8216 | 1.4876 | 1.7818 | 232.3 |
| | 360.00 | 17.958 | 552.0 | 1.9248 | 1.5617 | 1.8295 | 242.9 |
| | 380.00 | 16.700 | 589.1 | 2.0251 | 1.6336 | 1.8823 | 252.4 |
| | 400.00 | 15.640 | 627.3 | 2.1230 | 1.7031 | 1.9374 | 261.2 |
| | 420.00 | 14.731 | 666.6 | 2.2189 | 1.7702 | 1.9933 | 269.4 |
| | 440.00 | 13.940 | 707.0 | 2.3129 | 1.8350 | 2.0490 | 277.0 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .400 MASS FRACTION R22
= .254 MOLE FRACTION R22

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 293.52 | 629.030 | 127.9 | .5453 | 1.6935 | 2.0906 | 327.1 |
| SAT VAP | 294.80 | 27.576 | 392.6 | 1.4451 | 1.1285 | 1.4894 | 193.3 |
| | 300.00 | 26.678 | 400.3 | 1.4711 | 1.1455 | 1.4870 | 197.1 |
| | 320.00 | 23.872 | 430.1 | 1.5673 | 1.2102 | 1.4994 | 210.0 |
| | 340.00 | 21.751 | 460.4 | 1.6591 | 1.2732 | 1.5301 | 221.0 |
| | 360.00 | 20.062 | 491.4 | 1.7476 | 1.3344 | 1.5692 | 230.8 |
| | 380.00 | 18.672 | 523.2 | 1.8336 | 1.3937 | 1.6124 | 239.7 |
| | 400.00 | 17.498 | 555.9 | 1.9175 | 1.4510 | 1.6575 | 247.8 |
| | 420.00 | 16.489 | 589.5 | 1.9994 | 1.5064 | 1.7033 | 255.5 |
| | 440.00 | 15.608 | 624.0 | 2.0797 | 1.5597 | 1.7489 | 262.6 |

## TABLE A.10 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-290 MIXTURE (Concluded)

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .600 MASS FRACTION R22
= .433 MOLE FRACTION R22

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 291.68 | 738.142 | 111.7 | .4872 | 1.4332 | 1.8021 | 309.7 |
| SAT VAP | 292.06 | 31.623 | 344.4 | 1.2845 | .9377 | 1.2513 | 181.8 |
| | 300.00 | 30.087 | 354.3 | 1.3180 | .9583 | 1.2474 | 187.1 |
| | 320.00 | 26.996 | 379.3 | 1.3987 | 1.0093 | 1.2567 | 198.8 |
| | 340.00 | 24.639 | 404.7 | 1.4755 | 1.0590 | 1.2801 | 208.9 |
| | 360.00 | 22.752 | 430.6 | 1.5495 | 1.1073 | 1.3102 | 217.9 |
| | 380.00 | 21.192 | 457.1 | 1.6213 | 1.1540 | 1.3436 | 226.1 |
| | 400.00 | 19.872 | 484.3 | 1.6911 | 1.1991 | 1.3785 | 233.7 |
| | 420.00 | 18.734 | 512.3 | 1.7592 | 1.2426 | 1.4140 | 240.7 |
| | 440.00 | 17.740 | 540.9 | 1.8258 | 1.2845 | 1.4494 | 247.4 |

SUPERHEATED VAPOR PROPERTIES FOR R22 /R290
MIXING COEFFICIENT = .072
COMPOSITION = .800 MASS FRACTION R22
= .671 MOLE FRACTION R22

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 291.45 | 905.240 | 93.6 | .4055 | 1.1904 | 1.5164 | 295.0 |
| SAT VAP | 291.62 | 36.487 | 299.4 | 1.1114 | .7555 | 1.0178 | 171.0 |
| | 300.00 | 34.660 | 307.9 | 1.1401 | .7714 | 1.0133 | 176.0 |
| | 320.00 | 31.167 | 328.2 | 1.2056 | .8088 | 1.0174 | 186.6 |
| | 340.00 | 28.484 | 348.7 | 1.2677 | .8452 | 1.0325 | 195.8 |
| | 360.00 | 26.327 | 369.6 | 1.3273 | .8804 | 1.0529 | 204.0 |
| | 380.00 | 24.538 | 390.8 | 1.3848 | .9145 | 1.0761 | 211.6 |
| | 400.00 | 23.020 | 412.6 | 1.4406 | .9474 | 1.1006 | 218.5 |
| | 420.00 | 21.710 | 434.9 | 1.4949 | .9791 | 1.1256 | 225.0 |
| | 440.00 | 20.564 | 457.6 | 1.5478 | 1.0095 | 1.1507 | 231.1 |

## TABLE A.11 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-12 MIXTURE

DEW/BUBBLE LINES AT T = 273.1 K
COMPONENT A: R22 COMPONENT B: R12
MIXING COEFFICIENT, F = .0410

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 307.74 | .08661 | 6.742 | 4420.7 | 22791.2 | 17.406 | 84.673 | 100.255 | 61.658 | 114.014 | 73.618 |
| .1000 | .1926 | 348.58 | .08536 | 5.919 | 4566.1 | 22556.8 | 20.302 | 87.593 | 98.014 | 58.822 | 112.534 | 71.066 |
| .2000 | .3332 | 383.10 | .08400 | 5.360 | 4676.3 | 22379.8 | 21.883 | 87.924 | 95.841 | 56.755 | 111.094 | 69.256 |
| .3000 | .4428 | 412.10 | .08250 | 4.962 | 4748.1 | 22239.9 | 22.847 | 87.649 | 93.746 | 55.145 | 109.686 | 67.866 |
| .4000 | .5330 | 436.27 | .08086 | 4.672 | 4778.0 | 22125.4 | 23.322 | 87.144 | 91.739 | 53.819 | 108.302 | 66.718 |
| .5000 | .6112 | 456.17 | .07907 | 4.457 | 4762.0 | 22028.6 | 23.350 | 86.531 | 89.831 | 52.665 | 106.930 | 65.702 |
| .6000 | .6826 | 472.23 | .07710 | 4.298 | 4695.9 | 21944.2 | 22.935 | 85.846 | 88.035 | 51.605 | 105.561 | 64.736 |
| .7000 | .7518 | 484.65 | .07495 | 4.185 | 4574.7 | 21868.0 | 22.051 | 85.072 | 86.366 | 50.573 | 104.186 | 63.750 |
| .8000 | .8232 | 493.33 | .07263 | 4.113 | 4393.0 | 21796.3 | 20.632 | 84.139 | 84.838 | 49.499 | 102.799 | 62.669 |
| .9000 | .9029 | 497.59 | .07013 | 4.084 | 4144.9 | 21724.6 | 18.529 | 82.856 | 83.468 | 48.293 | 101.402 | 61.386 |
| 1.0000 | 1.0000 | 495.71 | .06746 | 4.114 | 3823.7 | 21647.2 | 15.021 | 80.285 | 82.274 | 46.812 | 100.002 | 59.732 |

DEW/BUBBLE LINES AT T = 283.1 K
COMPONENT A: R22 COMPONENT B: R12
MIXING COEFFICIENT, F = .0410

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 421.99 | .08869 | 4.977 | 5573.8 | 23299.2 | 21.517 | 84.129 | 101.142 | 63.199 | 116.038 | 76.440 |
| .1000 | .1857 | 474.98 | .08750 | 4.393 | 5704.9 | 23034.7 | 24.358 | 86.895 | 98.893 | 60.446 | 114.680 | 74.069 |
| .2000 | .3245 | 520.38 | .08619 | 3.986 | 5801.1 | 22830.0 | 25.886 | 87.189 | 96.714 | 58.393 | 113.364 | 72.368 |
| .3000 | .4345 | 559.04 | .08474 | 3.692 | 5859.2 | 22665.2 | 26.798 | 86.881 | 94.615 | 56.767 | 112.080 | 71.050 |
| .4000 | .5263 | 591.70 | .08313 | 3.474 | 5875.6 | 22528.5 | 27.223 | 86.334 | 92.607 | 55.409 | 110.814 | 69.948 |
| .5000 | .6066 | 618.97 | .08134 | 3.310 | 5846.2 | 22412.0 | 27.202 | 85.671 | 90.702 | 54.216 | 109.547 | 68.957 |
| .6000 | .6802 | 641.31 | .07935 | 3.188 | 5766.6 | 22310.2 | 26.738 | 84.926 | 88.915 | 53.115 | 108.265 | 67.996 |
| .7000 | .7514 | 658.91 | .07717 | 3.100 | 5631.8 | 22218.7 | 25.805 | 84.086 | 87.259 | 52.042 | 106.952 | 66.999 |
| .8000 | .8244 | 671.62 | .07479 | 3.042 | 5436.4 | 22133.7 | 24.337 | 83.081 | 85.752 | 50.931 | 105.596 | 65.887 |
| .9000 | .9046 | 678.62 | .07220 | 3.016 | 5174.3 | 22051.0 | 22.184 | 81.727 | 84.410 | 49.700 | 104.196 | 64.557 |
| 1.0000 | 1.0000 | 677.94 | .06942 | 3.031 | 4839.0 | 21965.0 | 18.627 | 79.122 | 83.253 | 48.219 | 102.756 | 62.851 |

## TABLE A.11 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-12 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 293.1 K
COMPONENT A: R22 COMPONENT B: R12
MIXING COEFFICIENT, F = .0410

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 565.27 | .09098 | 3.742 | 6747.9 | 23780.0 | 25.548 | 83.658 | 101.924 | 64.768 | 118.281 | 79.681 |
| .1000 | .1791 | 632.68 | .08988 | 3.318 | 6865.9 | 23485.1 | 28.339 | 86.273 | 99.667 | 62.104 | 117.085 | 77.535 |
| .2000 | .3160 | 691.18 | .08863 | 3.016 | 6949.3 | 23251.5 | 29.820 | 86.523 | 97.481 | 60.076 | 115.938 | 75.992 |
| .3000 | .4263 | 741.66 | .08723 | 2.793 | 6994.8 | 23060.1 | 30.686 | 86.178 | 95.376 | 58.442 | 114.821 | 74.793 |
| .4000 | .5195 | 784.86 | .08566 | 2.626 | 6998.8 | 22899.1 | 31.065 | 85.586 | 93.366 | 57.060 | 113.715 | 73.781 |
| .5000 | .6017 | 821.42 | .08388 | 2.499 | 6957.0 | 22760.8 | 31.000 | 84.869 | 91.463 | 55.834 | 112.594 | 72.853 |
| .6000 | .6775 | 851.79 | .08189 | 2.403 | 6864.8 | 22639.7 | 30.491 | 84.062 | 89.682 | 54.696 | 111.431 | 71.930 |
| .7000 | .7507 | 876.13 | .07967 | 2.333 | 6717.1 | 22531.4 | 29.513 | 83.154 | 88.040 | 53.585 | 110.201 | 70.940 |
| .8000 | .8252 | 894.21 | .07721 | 2.286 | 6508.2 | 22432.0 | 27.999 | 82.078 | 86.554 | 52.440 | 108.885 | 69.806 |
| .9000 | .9059 | 905.05 | .07453 | 2.264 | 6232.3 | 22337.7 | 25.799 | 80.654 | 85.242 | 51.183 | 107.473 | 68.425 |
| 1.0000 | 1.0000 | 906.42 | .07162 | 2.271 | 5882.6 | 22243.5 | 22.194 | 78.014 | 84.124 | 49.700 | 105.972 | 66.642 |

DEW/BUBBLE LINES AT T = 303.1 K
COMPONENT A: R22 COMPONENT B: R12
MIXING COEFFICIENT, F = .0410

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 741.67 | .09354 | 2.858 | 7944.7 | 24228.4 | 29.509 | 83.232 | 102.595 | 66.378 | 120.844 | 83.489 |
| .1000 | .1727 | 825.94 | .09253 | 2.543 | 8051.0 | 23902.6 | 32.256 | 85.695 | 100.326 | 63.812 | 119.869 | 81.632 |
| .2000 | .3075 | 899.99 | .09137 | 2.314 | 8123.1 | 23638.6 | 33.694 | 85.896 | 98.130 | 61.819 | 118.952 | 80.318 |
| .3000 | .4180 | 964.68 | .09005 | 2.143 | 8157.6 | 23418.5 | 34.520 | 85.509 | 96.018 | 60.188 | 118.069 | 79.309 |
| .4000 | .5124 | 1020.77 | .08853 | 2.012 | 8150.7 | 23230.9 | 34.861 | 84.868 | 94.002 | 58.791 | 117.188 | 78.455 |
| .5000 | .5965 | 1068.84 | .08678 | 1.912 | 8097.8 | 23068.6 | 34.756 | 84.094 | 92.099 | 57.540 | 116.272 | 77.650 |
| .6000 | .6743 | 1109.31 | .08479 | 1.836 | 7994.1 | 22926.0 | 34.208 | 83.223 | 90.323 | 56.371 | 115.279 | 76.811 |
| .7000 | .7494 | 1142.26 | .08253 | 1.779 | 7834.3 | 22798.9 | 33.188 | 82.244 | 88.694 | 55.226 | 114.167 | 75.862 |
| .8000 | .8256 | 1167.33 | .07999 | 1.741 | 7612.5 | 22683.9 | 31.631 | 81.095 | 87.228 | 54.048 | 112.902 | 74.722 |
| .9000 | .9070 | 1183.38 | .07719 | 1.721 | 7322.6 | 22577.3 | 29.386 | 79.602 | 85.947 | 52.767 | 111.468 | 73.28 |
| 1.0000 | 1.0000 | 1187.87 | .07412 | 1.724 | 6958.2 | 22475.0 | 25.733 | 76.927 | 84.871 | 51.278 | 109.866 | 71.386 |

## TABLE A.11 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-12 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 313.1 K
COMPONENT A: R22 COMPONENT B: R12
MIXING COEFFICIENT, F = .0410

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL | FRAC A) | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 955.40 | .09641 | 2.210 | 9166.8 | 24638.6 | 33.409 | 82.824 | 103.143 | 68.047 | 123.880 | 88.080 |
| .1000 | .1665 | 1059.11 | .09553 | 1.972 | 9263.3 | 24281.1 | 36.120 | 85.135 | 100.861 | 65.589 | 123.213 | 86.609 |
| .2000 | .2991 | 1151.33 | .09449 | 1.796 | 9326.0 | 23985.0 | 37.523 | 85.281 | 98.651 | 63.644 | 122.624 | 85.631 |
| .3000 | .4095 | 1232.89 | .09327 | 1.662 | 9351.5 | 23733.7 | 38.316 | 84.846 | 96.526 | 62.028 | 122.078 | 84.923 |
| .4000 | .5050 | 1304.48 | .09183 | 1.559 | 9335.5 | 23516.9 | 38.623 | 84.152 | 94.502 | 60.627 | 121.529 | 84.334 |
| .5000 | .5907 | 1366.61 | .09013 | 1.478 | 9273.4 | 23327.6 | 38.486 | 83.316 | 92.594 | 59.360 | 120.917 | 83.750 |
| .6000 | .6706 | 1419.58 | .08814 | 1.417 | 9159.8 | 23160.7 | 37.904 | 82.376 | 90.820 | 58.166 | 120.176 | 83.078 |
| .7000 | .7477 | 1463.36 | .08584 | 1.371 | 8988.9 | 23012.7 | 36.848 | 81.325 | 89.200 | 56.993 | 119.238 | 82.228 |
| .8000 | .8255 | 1497.39 | .08322 | 1.339 | 8754.8 | 22880.4 | 35.251 | 80.101 | 87.755 | 55.785 | 118.046 | 81.105 |
| .9000 | .9077 | 1520.31 | .08028 | 1.323 | 8451.0 | 22760.8 | 32.962 | 78.538 | 86.506 | 54.479 | 116.566 | 79.592 |
| 1.0000 | 1.0000 | 1529.27 | .07703 | 1.323 | 8071.0 | 22650.7 | 29.261 | 75.827 | 85.474 | 52.982 | 114.800 | 77.527 |

DEW/BUBBLE LINES AT T = 323.1 K
COMPONENT A: R22 COMPONENT B: R12
MIXING COEFFICIENT, F = .0410

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL | FRAC A) | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 1210.67 | .09970 | 1.727 | 10417.6 | 25004.1 | 37.263 | 82.408 | 103.558 | 69.795 | 127.629 | 93.783 |
| .1000 | .1604 | 1336.51 | .09898 | 1.545 | 10506.6 | 24613.5 | 39.943 | 84.563 | 101.255 | 67.457 | 127.413 | 92.851 |
| .2000 | .2906 | 1449.72 | .09810 | 1.407 | 10562.6 | 24282.9 | 41.320 | 84.648 | 99.026 | 65.576 | 127.311 | 92.383 |
| .3000 | .4006 | 1551.02 | .09702 | 1.300 | 10581.7 | 23997.6 | 42.088 | 84.160 | 96.883 | 63.992 | 127.276 | 92.159 |
| .4000 | .4970 | 1641.02 | .09569 | 1.217 | 10559.4 | 23748.0 | 42.372 | 83.406 | 94.842 | 62.600 | 127.238 | 92.018 |
| .5000 | .5844 | 1720.10 | .09407 | 1.152 | 10490.5 | 23528.2 | 42.210 | 82.503 | 92.923 | 61.328 | 127.105 | 91.829 |
| .6000 | .6662 | 1788.37 | .09212 | 1.101 | 10369.1 | 23333.7 | 41.601 | 81.489 | 91.146 | 60.119 | 126.767 | 91.471 |
| .7000 | .7454 | 1845.57 | .08979 | 1.064 | 10188.8 | 23161.8 | 40.514 | 80.360 | 89.532 | 58.922 | 126.108 | 90.826 |
| .8000 | .8249 | 1890.91 | .08706 | 1.038 | 9943.1 | 23010.1 | 38.881 | 79.059 | 88.105 | 57.689 | 125.026 | 89.770 |
| .9000 | .9082 | 1922.70 | .08395 | 1.023 | 9625.2 | 22876.7 | 36.549 | 77.426 | 86.889 | 56.358 | 123.461 | 88.159 |
| 1.0000 | 1.0000 | 1937.77 | .08046 | 1.023 | 9228.6 | 22759.2 | 32.799 | 74.677 | 85.906 | 54.848 | 121.412 | 85.819 |

## TABLE A.11 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-12 MIXTURE (CONTINUED)

DEW/BUBBLE LINES AT T = 333.1 K
COMPONENT A: R22 COMPONENT B: R12
MIXING COEFFICIENT, F = .0410

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 1511.73 | .10351 | 1.360 | 11701.8 | 25316.9 | 41.084 | 81.957 | 103.820 | 71.647 | 132.497 | 101.123 |
| .1000 | .1542 | 1662.45 | .10302 | 1.218 | 11786.7 | 24891.1 | 43.745 | 83.951 | 101.490 | 69.446 | 132.971 | 100.990 |
| .2000 | .2818 | 1799.57 | .10236 | 1.109 | 11839.6 | 24522.9 | 45.105 | 83.965 | 99.232 | 67.649 | 133.636 | 101.329 |
| .3000 | .3913 | 1923.72 | .10149 | 1.023 | 11856.1 | 24199.5 | 45.859 | 83.415 | 97.060 | 66.114 | 134.427 | 101.918 |
| .4000 | .4884 | 2035.33 | .10034 | .955 | 11831.4 | 23912.7 | 46.130 | 82.594 | 94.994 | 64.751 | 135.240 | 102.570 |
| .5000 | .5773 | 2134.59 | .09885 | .902 | 11759.3 | 23657.5 | 45.955 | 81.616 | 93.054 | 63.489 | 135.924 | 103.110 |
| .6000 | .6611 | 2221.35 | .09695 | .860 | 11633.3 | 23431.0 | 45.329 | 80.521 | 91.264 | 62.277 | 136.288 | 103.361 |
| .7000 | .7424 | 2295.03 | .09460 | .828 | 11446.0 | 23231.3 | 44.220 | 79.308 | 89.650 | 61.066 | 136.119 | 103.137 |
| .8000 | .8238 | 2354.44 | .09177 | .807 | 11189.8 | 23057.7 | 42.555 | 77.925 | 88.238 | 59.811 | 135.227 | 102.246 |
| .9000 | .9083 | 2397.51 | .08844 | .795 | 10857.5 | 22909.4 | 40.180 | 76.220 | 87.055 | 58.456 | 133.494 | 100.489 |
| 1.0000 | 1.0000 | 2420.63 | .08464 | .794 | 10442.4 | 22785.3 | 36.377 | 73.432 | 86.126 | 56.928 | 130.922 | 97.663 |

DEW/BUBBLE LINES AT T = 343.1 K
COMPONENT A: R22 COMPONENT B: R12
MIXING COEFFICIENT, F = .0410

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | ---------------- (KJ/KG MOL K) ---------------- | | | | | |
| .0000 | .0000 | 1862.80 | .10803 | 1.076 | 13026.7 | 25566.8 | 44.893 | 81.442 | 103.907 | 73.635 | 139.209 | 111.006 |
| .1000 | .1480 | 2041.14 | .10786 | .965 | 13112.3 | 25102.5 | 47.547 | 83.263 | 101.537 | 71.595 | 140.817 | 112.144 |
| .2000 | .2727 | 2205.19 | .10752 | .877 | 13167.2 | 24692.2 | 48.906 | 83.196 | 99.235 | 69.906 | 142.787 | 113.857 |
| .3000 | .3813 | 2355.43 | .10696 | .807 | 13186.9 | 24325.0 | 49.662 | 82.572 | 97.020 | 68.449 | 145.039 | 115.910 |
| .4000 | .4789 | 2492.11 | .10609 | .751 | 13165.6 | 23994.4 | 49.937 | 81.671 | 94.911 | 67.138 | 147.416 | 118.070 |
| .5000 | .5692 | 2615.16 | .10482 | .707 | 13096.3 | 23697.0 | 49.764 | 80.605 | 92.934 | 65.909 | 149.659 | 120.072 |
| .6000 | .6549 | 2724.06 | .10306 | .672 | 12970.8 | 23431.7 | 49.136 | 79.417 | 91.116 | 64.712 | 151.409 | 121.604 |
| .7000 | .7385 | 2817.75 | .10073 | .645 | 12780.2 | 23198.7 | 48.015 | 78.109 | 89.490 | 63.501 | 152.233 | 122.313 |
| .8000 | .8220 | 2894.51 | .09776 | .627 | 12515.3 | 22999.4 | 46.324 | 76.637 | 88.086 | 62.231 | 151.724 | 121.825 |
| .9000 | .9081 | 2951.70 | .09414 | .617 | 12167.9 | 22835.2 | 43.906 | 74.857 | 86.937 | 60.851 | 149.632 | 119.804 |
| 1.0000 | 1.0000 | 2985.21 | .08992 | .616 | 11731.2 | 22706.6 | 40.043 | 72.032 | 86.070 | 59.297 | 145.976 | 115.992 |

## TABLE A.11 - SATURATED VAPOR-LIQUID PROPERTIES OF R-22/R-12 MIXTURE (Concluded).

DEW/BUBBLE LINES AT T = 353.1 K
COMPONENT A: R22 COMPONENT B: R12
MIXING COEFFICIENT, F = .0410

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 2268.00 | .11355 | .854 | 14403.4 | 25739.8 | 48.718 | 80.824 | 103.780 | 75.806 | 149.182 | 125.140 |
| .1000 | .1416 | 2476.63 | .11385 | .765 | 14496.8 | 25231.3 | 51.386 | 82.456 | 101.350 | 73.957 | 152.846 | 128.516 |
| .2000 | .2629 | 2670.57 | .11401 | .694 | 14562.2 | 24771.6 | 52.765 | 82.288 | 98.983 | 72.415 | 157.303 | 132.827 |
| .3000 | .3703 | 2850.21 | .11395 | .636 | 14594.5 | 24351.5 | 53.549 | 81.569 | 96.697 | 71.074 | 162.498 | 137.848 |
| .4000 | .4681 | 3015.63 | .11356 | .589 | 14586.8 | 23966.6 | 53.855 | 80.567 | 94.517 | 69.855 | 168.215 | 143.282 |
| .5000 | .5597 | 3166.43 | .11270 | .551 | 14530.5 | 23615.7 | 53.712 | 79.391 | 92.473 | 68.696 | 173.999 | 148.683 |
| .6000 | .6474 | 3301.62 | .11123 | .521 | 14415.0 | 23300.6 | 53.107 | 78.088 | 90.600 | 67.545 | 177.078 | 153.394 |
| .7000 | .7334 | 3419.48 | .10900 | .499 | 14228.2 | 23025.1 | 51.993 | 76.666 | 88.939 | 66.355 | 182.402 | 156.551 |
| .8000 | .8194 | 3517.50 | .10588 | .483 | 13958.0 | 22794.4 | 50.285 | 75.092 | 87.532 | 65.080 | 182.891 | 157.195 |
| .9000 | .9074 | 3592.22 | .10185 | .475 | 13593.9 | 22613.4 | 47.822 | 73.235 | 86.419 | 63.673 | 179.871 | 154.537 |
| 1.0000 | 1.0000 | 3638.86 | .09698 | .475 | 13129.0 | 22484.9 | 43.883 | 70.379 | 85.629 | 62.077 | 173.469 | 148.238 |

DEW/BUBBLE LINES AT T = 363.1 K
COMPONENT A: R22 COMPONENT B: R12
MIXING COEFFICIENT, F = .0410

| XL | XV | P | VL | VV | HL | HV | SL | SV | CVL | CVV | CPL | CPV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (MOL FRAC A) | | (KPA) | (L/MOL) | | (KJ/KG MOL) | | (KJ/KG MOL K) | | | | | |
| .0000 | .0000 | 2731.38 | .12054 | .676 | 15850.5 | 25814.2 | 52.608 | 80.049 | 103.381 | 78.228 | 165.591 | 147.211 |
| .1000 | .1348 | 2972.64 | .12160 | .604 | 15964.2 | 25251.4 | 55.320 | 81.461 | 100.856 | 76.621 | 173.570 | 155.164 |
| .2000 | .2522 | 3199.22 | .12260 | .545 | 16055.0 | 24728.9 | 56.759 | 81.156 | 98.381 | 75.285 | 183.676 | 165.298 |
| .3000 | .3577 | 3411.46 | .12345 | .497 | 16117.7 | 24239.1 | 57.616 | 80.305 | 95.975 | 74.126 | 196.186 | 177.666 |
| .4000 | .4553 | 3609.31 | .12400 | .457 | 16144.3 | 23779.6 | 58.006 | 79.157 | 93.665 | 73.070 | 211.108 | 192.134 |
| .5000 | .5478 | 3792.10 | .12404 | .424 | 16123.4 | 23352.1 | 57.953 | 77.820 | 91.490 | 72.054 | 227.793 | 208.055 |
| .6000 | .6376 | 3958.29 | .12329 | .397 | 16039.6 | 22963.7 | 57.428 | 76.350 | 89.498 | 71.017 | 244.344 | 223.796 |
| .7000 | .7264 | 4105.28 | .12143 | .377 | 15873.8 | 22625.7 | 56.367 | 74.770 | 87.752 | 69.898 | 257.187 | 236.328 |
| .8000 | .8155 | 4229.37 | .11819 | .364 | 15606.1 | 22352.4 | 54.664 | 73.067 | 86.315 | 68.641 | 261.783 | 241.616 |
| .9000 | .9062 | 4325.81 | .11347 | .358 | 15220.6 | 22155.9 | 52.143 | 71.134 | 85.245 | 67.195 | 255.145 | 236.430 |
| 1.0000 | 1.0000 | 4388.87 | .10741 | .360 | 14710.8 | 22041.6 | 48.085 | 68.275 | 84.574 | 65.514 | 238.362 | 220.622 |

## TABLE A.12 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-12 MIXTURE

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = .041
COMPOSITION = .200 MASS FRACTION R12
= .152 MOLE FRACTION R12
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 231.53 | 1420.746 | 2.4 | .0406 | .8653 | 1.0167 | 399.5 |
| SAT VAP | 231.53 | 4.927 | 219.1 | .9764 | .4747 | .5777 | 154.5 |
| | 240.00 | 4.736 | 224.0 | .9974 | .4861 | .5879 | 157.4 |
| | 260.00 | 4.343 | 236.0 | 1.0454 | .5122 | .6119 | 163.9 |
| | 280.00 | 4.013 | 248.5 | 1.0916 | .5373 | .6355 | 170.1 |
| | 300.00 | 3.731 | 261.5 | 1.1362 | .5615 | .6584 | 176.0 |
| | 320.00 | 3.485 | 274.9 | 1.1794 | .5847 | .6806 | 181.6 |
| | 340.00 | 3.275 | 288.7 | 1.2213 | .6070 | .7021 | 187.0 |
| | 360.00 | 3.088 | 302.9 | 1.2621 | .6282 | .7227 | 192.3 |
| | 380.00 | 2.921 | 317.6 | 1.3017 | .6486 | .7424 | 197.3 |
| | 400.00 | 2.772 | 332.6 | 1.3402 | .6679 | .7613 | 202.3 |
| | 420.00 | 2.637 | 348.0 | 1.3778 | .6863 | .7793 | 207.0 |
| | 440.00 | 2.516 | 363.8 | 1.4145 | .7038 | .7964 | 211.7 |

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = 041
COMPOSITION = .400 MASS FRACTION R12
= .323 MOLE FRACTION R12
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 231.91 | 1430.033 | 5.0 | .0621 | .8413 | .9815 | 383.2 |
| SAT VAP | 232.41 | 5.231 | 207.0 | .9326 | .4717 | .5690 | 149.1 |
| | 240.00 | 5.049 | 211.4 | .9511 | .4816 | .5779 | 151.7 |
| | 260.00 | 4.628 | 223.2 | .9983 | .5070 | .6012 | 158.1 |
| | 280.00 | 4.275 | 235.4 | 1.0436 | .5313 | .6239 | 164.1 |
| | 300.00 | 3.974 | 248.1 | 1.0874 | .5545 | .6459 | 169.9 |
| | 320.00 | 3.714 | 261.2 | 1.1298 | .5766 | .6670 | 175.4 |
| | 340.00 | 3.488 | 274.8 | 1.1709 | .5977 | .6873 | 180.7 |
| | 360.00 | 3.288 | 288.7 | 1.2107 | .6177 | .7066 | 185.8 |
| | 380.00 | 3.110 | 303.0 | 1.2494 | .6366 | .7249 | 190.7 |
| | 400.00 | 2.951 | 317.7 | 1.2870 | .6544 | .7423 | 195.5 |
| | 420.00 | 2.808 | 332.7 | 1.3236 | .6711 | .7586 | 200.2 |
| | 440.00 | 2.678 | 348.1 | 1.3593 | .6868 | .7739 | 204.7 |

## TABLE A.12 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-12 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = .041
COMPOSITION = .600 MASS FRACTION R12
= .518 MOLE FRACTION R12
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 233.11 | 1445.020 | 6.2 | .0688 | .8221 | .9492 | 368.3 |
| SAT VAP | 235.12 | 5.531 | 195.9 | .8798 | .4710 | .5624 | 144.2 |
| | 240.00 | 5.407 | 198.7 | .8914 | .4772 | .5680 | 145.8 |
| | 260.00 | 4.954 | 210.3 | .9377 | .5019 | .5905 | 152.1 |
| | 280.00 | 4.574 | 222.3 | .9823 | .5253 | .6124 | 158.0 |
| | 300.00 | 4.252 | 234.8 | 1.0253 | .5475 | .6334 | 163.6 |
| | 320.00 | 3.973 | 247.6 | 1.0668 | .5686 | .6534 | 168.9 |
| | 340.00 | 3.730 | 260.9 | 1.1070 | .5884 | .6725 | 174.1 |
| | 360.00 | 3.516 | 274.5 | 1.1459 | .6071 | .6905 | 179.1 |
| | 380.00 | 3.325 | 288.5 | 1.1837 | .6246 | .7074 | 183.9 |
| | 400.00 | 3.155 | 302.8 | 1.2204 | .6408 | .7232 | 188.6 |
| | 420.00 | 3.002 | 317.4 | 1.2561 | .6559 | .7379 | 193.1 |
| | 440.00 | 2.863 | 332.3 | 1.2907 | .6698 | .7514 | 197.5 |

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = .041
COMPOSITION = .800 MASS FRACTION R12
= .741 MOLE FRACTION R12
PRESSURE = 100.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 235.90 | 1465.793 | 6.7 | .0624 | .8084 | .9206 | 354.3 |
| SAT VAP | 238.88 | 5.853 | 185.3 | .8146 | .4715 | .5570 | 139.4 |
| | 240.00 | 5.822 | 186.0 | .8172 | .4728 | .5583 | 139.7 |
| | 260.00 | 5.331 | 197.4 | .8628 | .4967 | .5800 | 145.8 |
| | 280.00 | 4.920 | 209.2 | .9065 | .5193 | .6010 | 151.6 |
| | 300.00 | 4.572 | 221.4 | .9487 | .5406 | .6210 | 157.1 |
| | 320.00 | 4.271 | 234.0 | .9894 | .5606 | .6399 | 162.3 |
| | 340.00 | 4.009 | 247.0 | 1.0287 | .5792 | .6578 | 167.3 |
| | 360.00 | 3.778 | 260.3 | 1.0668 | .5965 | .6745 | 172.2 |
| | 380.00 | 3.573 | 273.9 | 1.1037 | .6126 | .6899 | 176.8 |
| | 400.00 | 3.390 | 287.9 | 1.1394 | .6273 | .7042 | 181.4 |
| | 420.00 | 3.225 | 302.1 | 1.1741 | .6407 | .7172 | 185.8 |
| | 440.00 | 3.075 | 316.6 | 1.2077 | .6528 | .7290 | 190.1 |

# TABLE A.12 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-12 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = .041
COMPOSITION = .200 MASS FRACTION R12
= .152 MOLE FRACTION R12

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 266.58 | 1306.519 | 39.5 | .1885 | .9106 | 1.0959 | 328.8 |
| SAT VAP | 266.61 | 18.207 | 234.9 | .9215 | .5258 | .6593 | 157.6 |
| | 280.00 | 17.074 | 243.8 | .9541 | .5424 | .6694 | 162.9 |
| | 300.00 | 15.659 | 257.3 | 1.0008 | .5665 | .6861 | 170.2 |
| | 320.00 | 14.490 | 271.2 | 1.0457 | .5896 | .7038 | 176.9 |
| | 340.00 | 13.503 | 285.5 | 1.0889 | .6118 | .7219 | 183.2 |
| | 360.00 | 12.655 | 300.1 | 1.1306 | .6330 | .7399 | 189.1 |
| | 380.00 | 11.918 | 315.1 | 1.1711 | .6533 | .7575 | 194.7 |
| | 400.00 | 11.268 | 330.4 | 1.2104 | .6726 | .7747 | 200.0 |
| | 420.00 | 10.691 | 346.1 | 1.2486 | .6909 | .7912 | 205.2 |
| | 440.00 | 10.174 | 362.0 | 1.2858 | .7082 | .8071 | 210.1 |

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = .041
COMPOSITION = .400 MASS FRACTION R12
= .323 MOLE FRACTION R12

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 267.38 | 1313.652 | 41.1 | .2061 | .8831 | 1.0563 | 314.5 |
| SAT VAP | 268.07 | 19.340 | 222.9 | .8854 | .5222 | .6495 | 152.0 |
| | 280.00 | 18.254 | 230.7 | .9138 | .5365 | .6578 | 156.6 |
| | 300.00 | 16.724 | 244.0 | .9598 | .5595 | .6735 | 163.9 |
| | 320.00 | 15.464 | 257.7 | 1.0037 | .5815 | .6900 | 170.5 |
| | 340.00 | 14.403 | 271.6 | 1.0461 | .6025 | .7069 | 176.6 |
| | 360.00 | 13.494 | 285.9 | 1.0870 | .6224 | .7235 | 182.4 |
| | 380.00 | 12.703 | 300.6 | 1.1265 | .6412 | .7397 | 187.9 |
| | 400.00 | 12.008 | 315.5 | 1.1649 | .6589 | .7553 | 193.2 |
| | 420.00 | 11.391 | 330.8 | 1.2021 | .6755 | .7702 | 198.2 |
| | 440.00 | 10.838 | 346.3 | 1.2382 | .6911 | .7843 | 203.1 |

## TABLE A.12 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-12 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = .041
COMPOSITION = .600 MASS FRACTION R12
= .518 MOLE FRACTION R12

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 269.24 | 1327.270 | 41.8 | .2097 | .8610 | 1.0188 | 301.6 |
| SAT VAP | 271.39 | 20.472 | 212.1 | .8400 | .5207 | .6412 | 146.8 |
| | 280.00 | 19.629 | 217.6 | .8601 | .5306 | .6468 | 150.1 |
| | 300.00 | 17.958 | 230.7 | .9052 | .5526 | .6612 | 157.2 |
| | 320.00 | 16.589 | 244.1 | .9484 | .5735 | .6765 | 163.8 |
| | 340.00 | 15.439 | 257.7 | .9898 | .5932 | .6921 | 169.9 |
| | 360.00 | 14.457 | 271.7 | 1.0298 | .6117 | .7074 | 175.6 |
| | 380.00 | 13.604 | 286.0 | 1.0685 | .6291 | .7221 | 181.0 |
| | 400.00 | 12.855 | 300.6 | 1.1059 | .6452 | .7362 | 186.1 |
| | 420.00 | 12.191 | 315.5 | 1.1421 | .6602 | .7494 | 191.0 |
| | 440.00 | 11.598 | 330.6 | 1.1773 | .6740 | .7617 | 195.8 |

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = .041
COMPOSITION = .800 MASS FRACTION R12
= .741 MOLE FRACTION R12

PRESSURE = 400.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 273.03 | 1347.360 | 42.1 | .2008 | .8446 | .9844 | 289.1 |
| SAT VAP | 275.99 | 21.681 | 201.9 | .7826 | .5204 | .6342 | 141.6 |
| | 280.00 | 21.257 | 204.4 | .7918 | .5248 | .6365 | 143.1 |
| | 300.00 | 19.409 | 217.3 | .8361 | .5458 | .6494 | 150.3 |
| | 320.00 | 17.904 | 230.4 | .8785 | .5655 | .6634 | 156.8 |
| | 340.00 | 16.647 | 243.8 | .9191 | .5840 | .6776 | 162.8 |
| | 360.00 | 15.576 | 257.5 | .9583 | .6012 | .6915 | 168.4 |
| | 380.00 | 14.649 | 271.5 | .9960 | .6171 | .7047 | 173.7 |
| | 400.00 | 13.836 | 285.7 | 1.0325 | .6316 | .7172 | 178.7 |
| | 420.00 | 13.117 | 300.1 | 1.0678 | .6449 | .7287 | 183.6 |
| | 440.00 | 12.474 | 314.8 | 1.1019 | .6569 | .7392 | 188.2 |

## TABLE A.12 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-12 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = .041
COMPOSITION = .200 MASS FRACTION R12
= .152 MOLE FRACTION R12

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 284.29 | 1241.996 | 59.4 | .2599 | .9290 | 1.1482 | 294.6 |
| SAT VAP | 284.36 | 31.393 | 241.5 | .9006 | .5535 | .7193 | 156.8 |
| | 300.00 | 28.946 | 252.8 | .9392 | .5720 | .7228 | 163.9 |
| | 320.00 | 26.440 | 267.4 | .9862 | .5949 | .7324 | 171.9 |
| | 340.00 | 24.413 | 282.1 | 1.0309 | .6169 | .7451 | 179.1 |
| | 360.00 | 22.726 | 297.2 | 1.0739 | .6380 | .7592 | 185.8 |
| | 380.00 | 21.292 | 312.5 | 1.1154 | .6581 | .7740 | 192.0 |
| | 400.00 | 20.052 | 328.1 | 1.1554 | .6773 | .7890 | 197.8 |
| | 420.00 | 18.967 | 344.1 | 1.1943 | .6955 | .8038 | 203.3 |
| | 440.00 | 18.007 | 360.3 | 1.2320 | .7128 | .8182 | 208.5 |

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = .041
COMPOSITION = .400 MASS FRACTION R12
= .323 MOLE FRACTION R12

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 285.35 | 1247.505 | 60.6 | .2757 | .8998 | 1.1060 | 281.2 |
| SAT VAP | 286.14 | 33.377 | 229.7 | .8678 | .5495 | .7085 | 151.0 |
| | 300.00 | 31.026 | 239.5 | .9013 | .5651 | .7106 | 157.2 |
| | 320.00 | 28.291 | 253.8 | .9474 | .5868 | .7187 | 165.3 |
| | 340.00 | 26.092 | 268.3 | .9913 | .6075 | .7300 | 172.4 |
| | 360.00 | 24.269 | 283.0 | 1.0334 | .6272 | .7427 | 179.0 |
| | 380.00 | 22.724 | 298.0 | 1.0739 | .6459 | .7561 | 185.1 |
| | 400.00 | 21.391 | 313.3 | 1.1130 | .6635 | .7694 | 190.8 |
| | 420.00 | 20.226 | 328.8 | 1.1509 | .6800 | .7826 | 196.2 |
| | 440.00 | 19.196 | 344.6 | 1.1876 | .6955 | .7952 | 201.4 |

## TABLE A.12 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-12 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = .041
COMPOSITION = .600 MASS FRACTION R12
= .518 MOLE FRACTION R12

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 287.61 | 1259.994 | 60.9 | .2777 | .8762 | 1.0650 | 269.1 |
| SAT VAP | 289.80 | 35.363 | 219.0 | .8256 | .5474 | .6988 | 145.6 |
| | 300.00 | 33.484 | 226.2 | .8497 | .5583 | .6996 | 150.2 |
| | 320.00 | 30.460 | 240.2 | .8951 | .5788 | .7058 | 158.2 |
| | 340.00 | 28.047 | 254.4 | .9381 | .5983 | .7155 | 165.4 |
| | 360.00 | 26.057 | 268.9 | .9793 | .6166 | .7267 | 171.9 |
| | 380.00 | 24.377 | 283.5 | 1.0190 | .6338 | .7384 | 177.9 |
| | 400.00 | 22.933 | 298.4 | 1.0571 | .6498 | .7502 | 183.6 |
| | 420.00 | 21.673 | 313.5 | 1.0940 | .6646 | .7616 | 188.9 |
| | 440.00 | 20.561 | 328.8 | 1.1297 | .6782 | .7725 | 194.0 |

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = .041
COMPOSITION = .800 MASS FRACTION R12
= .741 MOLE FRACTION R12

PRESSURE = 700.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 291.98 | 1279.362 | 61.2 | .2675 | .8585 | 1.0265 | 257.3 |
| SAT VAP | 294.88 | 37.484 | 209.1 | .7716 | .5465 | .6903 | 140.3 |
| | 300.00 | 36.451 | 212.7 | .7835 | .5516 | .6901 | 142.6 |
| | 320.00 | 33.044 | 226.5 | .8281 | .5710 | .6940 | 150.7 |
| | 340.00 | 30.357 | 240.5 | .8704 | .5891 | .7017 | 157.9 |
| | 360.00 | 28.159 | 254.6 | .9108 | .6060 | .7112 | 164.4 |
| | 380.00 | 26.312 | 268.9 | .9495 | .6217 | .7213 | 170.4 |
| | 400.00 | 24.731 | 283.4 | .9868 | .6361 | .7313 | 176.0 |
| | 420.00 | 23.356 | 298.2 | 1.0227 | .6492 | .7410 | 181.3 |
| | 440.00 | 22.145 | 313.1 | 1.0574 | .6610 | .7500 | 186.2 |

## TABLE A.12 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-12 MIXTURE (CONTINUED)

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = .041
COMPOSITION = .200 MASS FRACTION R12
= .152 MOLE FRACTION R12

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 296.94 | 1191.674 | 74.2 | .3100 | .9398 | 1.1959 | 270.5 |
| SAT VAP | 297.04 | 44.899 | 245.5 | .8868 | .5748 | .7767 | 155.2 |
| | 300.00 | 44.099 | 247.8 | .8945 | .5782 | .7745 | 156.8 |
| | 320.00 | 39.580 | 263.2 | .9442 | .6006 | .7688 | 166.5 |
| | 340.00 | 36.131 | 278.6 | .9909 | .6223 | .7727 | 174.9 |
| | 360.00 | 33.368 | 294.1 | 1.0353 | .6431 | .7813 | 182.4 |
| | 380.00 | 31.082 | 309.8 | 1.0778 | .6631 | .7922 | 189.2 |
| | 400.00 | 29.147 | 325.8 | 1.1188 | .6821 | .8044 | 195.5 |
| | 420.00 | 27.480 | 342.0 | 1.1583 | .7002 | .8170 | 201.3 |
| | 440.00 | 26.022 | 358.5 | 1.1966 | .7174 | .8298 | 206.9 |

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = .041
COMPOSITION = .400 MASS FRACTION R12
= .323 MOLE FRACTION R12

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 298.22 | 1195.702 | 75.1 | .3245 | .9094 | 1.1518 | 257.8 |
| SAT VAP | 299.06 | 47.786 | 233.8 | .8561 | .5703 | .7653 | 149.3 |
| | 300.00 | 47.508 | 234.5 | .8585 | .5713 | .7644 | 149.8 |
| | 320.00 | 42.493 | 249.7 | .9074 | .5926 | .7559 | 159.6 |
| | 340.00 | 38.708 | 264.8 | .9533 | .6129 | .7579 | 168.0 |
| | 360.00 | 35.697 | 280.0 | .9968 | .6324 | .7648 | 175.4 |
| | 380.00 | 33.219 | 295.4 | 1.0384 | .6508 | .7742 | 182.2 |
| | 400.00 | 31.128 | 311.0 | 1.0783 | .6682 | .7847 | 188.4 |
| | 420.00 | 29.330 | 326.8 | 1.1169 | .6846 | .7957 | 194.2 |
| | 440.00 | 27.761 | 342.8 | 1.1542 | .6999 | .8066 | 199.7 |

## TABLE A.12 - SUPERHEATED VAPOR PROPERTIES OF R-22/R-12 MIXTURE (Concluded)

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = .041
COMPOSITION = .600 MASS FRACTION R12
= .518 MOLE FRACTION R12

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 300.79 | 1207.121 | 75.2 | .3254 | .8849 | 1.1077 | 246.1 |
| SAT VAP | 302.98 | 50.676 | 223.3 | .8160 | .5678 | .7543 | 143.7 |
| | 320.00 | 45.968 | 236.0 | .8569 | .5847 | .7447 | 152.2 |
| | 340.00 | 41.746 | 250.9 | .9020 | .6037 | .7442 | 160.6 |
| | 360.00 | 38.423 | 265.8 | .9447 | .6217 | .7491 | 168.1 |
| | 380.00 | 35.705 | 280.9 | .9854 | .6386 | .7567 | 174.8 |
| | 400.00 | 33.422 | 296.1 | 1.0244 | .6544 | .7655 | 181.0 |
| | 420.00 | 31.467 | 311.5 | 1.0620 | .6691 | .7747 | 186.8 |
| | 440.00 | 29.766 | 327.1 | 1.0982 | .6826 | .7838 | 192.1 |

SUPERHEATED VAPOR PROPERTIES FOR R12 /R22
MIXING COEFFICIENT = .041
COMPOSITION = .800 MASS FRACTION R12
= .741 MOLE FRACTION R12

PRESSURE = 1000.00 KPA

| | TEMP (K) | DENSITY (KG/M**3) | ENTHALPY (KJ/KG) | ENTROPY ----- | CV (KJ/KG K) | CP ----- | VSND (M/S) |
|---|---|---|---|---|---|---|---|
| SAT LIQ | 305.59 | 1225.736 | 75.4 | .3143 | .8663 | 1.0654 | 234.7 |
| SAT VAP | 308.43 | 53.762 | 213.6 | .7644 | .5664 | .7444 | 138.2 |
| | 320.00 | 50.217 | 222.2 | .7917 | .5770 | .7360 | 144.0 |
| | 340.00 | 45.403 | 236.8 | .8361 | .5946 | .7320 | 152.7 |
| | 360.00 | 41.668 | 251.5 | .8780 | .6112 | .7345 | 160.3 |
| | 380.00 | 38.643 | 266.2 | .9178 | .6266 | .7400 | 167.1 |
| | 400.00 | 36.120 | 281.1 | .9560 | .6407 | .7469 | 173.2 |
| | 420.00 | 33.970 | 296.1 | .9926 | .6536 | .7542 | 178.9 |
| | 440.00 | 32.106 | 311.3 | 1.0278 | .6653 | .7614 | 184.3 |

# APPENDIX B

# TELEPHONE CONVERSATIONS

1. Telephone conversation between L. R. Grzyll of Mainstream Engineering Corp. and Dr. Mark McLinden of the National Bureau of Standards (Boulder, CO), September 19, 1989.

2. Telephone conversation between L. R. Grzyll of Mainstream Engineering Corp. and J. Mossel of ICI Americas, August 30, 1989.

3. Telephone conversation between L. R. Grzyll of Mainstream Engineering Corp. and Mr. Pete Narreau of Carlyle Compressor Division of Carrier Corp., September 21, 1989.

## APPENDIX C

## HEAT PUMP COMPUTER SIMULATOR SOURCE CODE

```
      program binary

c     (C) Copyright Mainstream Engineering Corporation 1989

c     This is the main program for the Air Force Heat Pump
c     contract.  This program is used to determine the change
c     in capacity of a refrigeration system when the pure
c     refrigerant is replaced with a binary mixture.
c     The main program simply opens the output file where results
c     are logged, calls the required subroutines, and allows
c     for the simulation to be run again if desired.


c     developed 10/12/89 - JJS


      character*12 outnam
      character*1 again
      common/tol/tolr,itmax,lup

      write(*,*)'ENTER OUTPUT FILE NAME'
      read(*,22)outnam

      open(lup,file = outnam,status = 'unknown')

11    continue

      call hpump1

      write(*,1000)
      read(*,1001)again
      if(again .eq. 'y' .or. again .eq. 'Y')go to 11


22    format(a12)
1000  format(2x,'RUN ANOTHER CASE? <Y,N>')
1001  format(a1)

      close(lup)
      stop
      end
```

```
      subroutine hpump1

c     (C) Copyright Mainstream Engineering Corporation 1989

c     This program simulates a  heat pump model utilizing a
c     binary mixture of refrigerants.  The fluid properties are
c     determined using the NBS code and the required thermo-
c     dynamic properties are called through subroutine calls
c     as is required.
c     The simple heat pump model is illustrated below.  In this model,
c     first the TXV is neglected and is treated as a generic throttling
c     valve and the evaporator and valve are assumed one component.
c     Then the performance is predicted assuming that a TXV, charged with
c     fluid A, preceeds the evaporator.  This second analysis is performed
c     by the subroutine TXV.

c                        -----------------
c              1-------|    condenser    |-----2
c              |        -----------------      |
c              |                               |
c              |                               |
c              |                               |
c         -----------                          |
c         |  comp   |                          |
c         |         |                          |
c         -----------                          |
c              |                               |
c              |        ---------------        |
c              3-------|   evap/TXV    |------
c                       ---------------

c     Developed 10/14/89 - JJS

c     Other Subroutines Referenced

c     Subroutine                     Source

c      bconst                        NBS
c      bublt                         NBS
c      critx                         NBS
c      espar                         NBS
c      vit                           NBS
c      hcvcps                        NBS
c      txv                           Mainstream
c      spin                          NBS
c      vdot                          Mainstream

c     Other Functions Referenced

c     Function                       Source

c      entrop                        NBS

      real coeff(9,20), crit(5,20)
      character*6 href(20)
      logical lcrit,lv
      common/esdata/coeff,crit
      common/href1/href
      common/tol/tolr,itmax,lup
      common/txvdat/tevap,plotxv,xa,wcomp,cn,phi,tsup,wm
      real a(3,2),b(3,2)

12    continue
      write(*,*)'ENTER CODE NUMBERS FOR THE BINARY FLUID PAIR i1,i2'
      read(*,*)ir1,ir2
      ih1 = ir1
      ih2 = ir2
```

```
      write(*,*)'ENTER BINARY INTERACTION PARAMETER'
      read(*,*)f
      fhld = f

c                                               set condenser and evaporator
c                                               temps for simple model.
      tcond = 323.0
      tsub = 308.0

      tevap = 275.0
      tsup = 280.0

      write(*,*)'ENTER COMPRESSOR INPUT POWER IN W'
      read(*,*)WCOMP

      write(*,*)'ENTER COMPRESSOR OVERALL EFFICIENCY'
      read(*,*)cn


c                                               determine volumetric flow rate
c                                               of baseline system.  This will
c                                               be held constant throughout the
c                                               simulation and mass flow rates
c                                               of the mixtures will be det-
c                                               ermined from this and the mixture
c                                               density.

      call vdot(ir1,tsup,vflow,wcomp,cn)

     icount = 0
c                                               loop over mole fractions in
c                                               increments of 0.1
     do 22 xx= 0.0,1.01,.122
      icount = icount + 1
      if(icount .eq. 1) then
              ir1 = ir2
              f = 0.0
      else if(icount .eq. 11) then
              ir2 = ir1
              f = 0.0
      else
              ir1 = ih1
              ir2 = ih2
              f = fhld
      end if
      xxx = xx
      if(xx .gt. 1.0)xxx = 1.0

c                                               find plo as if a TXV were present
      if(icount .eq. 1) then
              call bconst(ih1,ih1,f,0.0)
              call bublt(tevap,xl,1.0,plotxv,vl,vvp,.false.,lcrit)
              write(lup,1000)href(ih1),href(ih2)
              write(lup,1002)
      end if

      call bconst(ir1,ir2,f,0.0)



c                                               determine molecular weight of
c                                               the mixture.
      wm1 = crit(1,ir1)
      wm2 = crit(1,ir2)
      xmol = xxx/wm1/(xxx/wm1 + (1.0 - xxx)/wm2)
      XA = XMOL
      XB = 1.0 - XMOL
      wm = xmol*wm1 + (1.0 - xmol)*wm2
c                                               wm = the molecular weight.

c                                               determine condenser and evap.
```

```
                                              pressures and enthalpy.
c                                             critx needs a guessed tcrit.
c                                             Guess tcrit = 350.0 K
      tcrit = 350.0
      call critx(xmol,tcrit,pcrit,vcrit)


      call bublt(tcond,xmol,xv,phi,vcnd,vv,.true.,lcrit)
      if(lcrit)then
             write(*,*)'Tcond greater than tcrit'
             qevap = 0.0
             cop = 0.0
             go to 688
      end if
      call espar(0,tsub,xmol,a,b)
      call vit(tsub,phi,a,b,vcnd,.true.,lv)
      call hcvcps(1,tsub,vcnd,xmol,hcnd,cv,cp,vsnd)
      h2 = hcnd/wm


c                                             find enthalpy and entropy at
c                                             evaporator outlet.
      call bublt(tevap,xl,xmol,plo,vl,vevp,.false.,lcrit)
      if(lcrit)then
             write(*,*)'Tevap greater than tcrit'
             qevap = 0.0
             cop = 0.0
             go to 688
      end if
      call espar(0,tsup,xmol,a,b)
      call vit(tsup,plo,a,b,vevp,.false.,lv)
c                                             vevp = evaporator specific vol.

      call hcvcps(1,tsup,vevp,xmol,hevp,cv,cp,vsnd)
      h3 = hevp/wm
      sevp = entrop(tsup,vevp,xmol)
      s3 = sevp/wm





c                                             now must find compressor flow
c                                             from p and s.
      tcrit = tcond
      call critx(xa,tcrit,pcrit,vcrit)
      if(phi .ge. pcrit) then
             qevap = 0.0
             cop = 0.0
             supno = 0.0
             go to 688
      end if

c                                             spin determines quality and
c                                             temperature given pressure
c                                             and entropy

      call spin(sevp,phi,xmol,t1s,xq,xl,xv,vl,vv,sl,sv)
      if(xq .ge. 1.0) then
             v1 = vv
      else if(xq .gt. 0.0) then
             write(lup,*)'COMPRESSOR OUTLET QUALITY = ',XQ
             v1 = vl + xq*(vv - vl)
      else
             WRITE(LUP,*)'COMPRESSOR OUTLET SUBCOOLED'
             v1 = vl
      end if
```

```
c                                              now get isentropic compressor
c                                              outlet enthalpy

      call hcvcps(1,t1s,v1,xmol,hcmps,cv,cp,vsnd)
      h1s = hcmps/wm

c                                              adjust isentropic enthalpy to
c                                              true enthalpy using the comp-
c                                              ressor efficiency
      h1 = h3 + (h1s - h3)/cn


      flow = vflow/vevp
      wcomp = 1000.0*flow*(h1 - h3)

      qevap = 1000.0*flow*(h3 - h2)
      qcond = 1000.0*flow*(h1 - h3)
      error = (qevap + wcomp - qcond)/qcond

      cop = qevap/wcomp
      supno = tsup - tevap

c                                              Here perform analysis as if a
c                                              TXV were there.
      call txv(qtx,coptx,sup,h2,tflow,vflow,wtxv)

c                                              TXV returns the coefficient of
c                                              performance, actual evaporator
c                                              outlet superheat, and cooling
c                                              load as if a TXV were present.

c                                              All pertinent data for the txv
c                                              model has been determined by
c                                              the subroutine txv.

688   continue

c                                              send results to output file

      write(lup,1004)xa,plotxv,plo
      write(lup,1006)phi,phi
      write(lup,1008)sup,supno
      write(lup,1010)coptx,cop
      write(lup,1011)wtxv,wcomp
      write(lup,1012)qtx,qevap
      write(lup,1013)tflow,flow

22    continue


1000  format(//,25x,'FLUID A - ',1X,a6,2x,'FLUID B - ',1x,a6,//)
1002  format(2x,'XA [mol%]',10x,'STAT',10x,'TXV',10x,'NO TXV',/
     1       2x,'---------',10x,'----',10x,'---',10x,'------')
1004  format(2x,f5.3,10x,'Plow [Kpa]',6x,f6.1,7x,f6.1)
1006  format(2x,' --- ',10x,'Phi [Kpa]',7x,f6.1,7x,f6.1)
1008  format(2x,' --- ',6x,'Superheat [C]',6x,f6.1,9x,f6.1)
1010  format(2x,' --- ',14x,'COPc',6x,f6.1,9x,f6.1)
1011  format(2x,' --- ',10x,'Wcomp [W]',6x,f9.0,4x,f9.0)
1012  format(2x,' --- ',10x,'Qevap [W]',6x,f9.0,4x,f9.0)
1013  format(2x,' --- ',10x,'FLOW [kg/s]',4x,f7.4 5x,f7.4,/)

      return
      end
```

```
      subroutine txv(qtx,cop,sup,h2,flow,vflow,wtxv)

c     (C) Copyright Mainstream Engineering Corporation 1989

c     this subroutine determines the capacity of a heat pump system
c     as if a real txv were used as the throttling device and it was
c     charged with the same fluid as was originally used in the
c     system (ie. R11 or R22).

c     developed 10/20/89 - JJS


      real coeff(9,20), crit(5,20)
      character*6 href(20)
      logical lcrit,lv
      common/esdata/coeff,crit
      common/href1/href
      common/tol/tolr,itmax,lup
      common/txvdat/tevap,plotxv,xa,wcomp,cn,phi,tsup,wm
      real a(3,2),b(3,2)

      call bublp(plotxv,xa,xvb,tbub,vlb,vvb,.true.,lcrit)
      if(lcrit)then
            qtx = 0.0
            cop = 0.0
            sup = 0.0
            go to 9999
      end if
      call bublp(plotxv,xld,xa,tdew,vld,vvd,.false.,lcrit)

      if(lcrit)then
            qtx = 0.0
            cop = 0.0
            sup = 0.0
            go to 9999
      end if


      sup = tsup - tdew

      call espar(0,tsup,xa,a,b)

c                                               If superheated at evaporator
c                                               outlet, get enthalpy and
c                                               entropy directly.
      if(tsup .ge. tdew) then
            call vit(tsup,plotxv,a,b,vvd,.false.,lv)
            call hcvcps(1,tsup,vvd,xa,havp,cv,cp,vsnd)
            sevp = entrop(tsup,vvd,xa)
            vevp = vvd

c                                               If two-phase at evaporator
c                                               outlet, must iterate to determine
c                                               the quality, enthalpy, and
c                                               entropy.  This is done by
c                                               guessing a quality, determining
c                                               enthalpy from the guessed quality,
c                                               then determining temperature
c                                               from the enthalpy and known
c                                               pressure.  When this temperature
c                                               matches the known evaporator
c                                               outlet temp., the iterations
c                                               have converged.
      else if (tsup .gt. tbub) then
            icount = 0
            xqg = (tsup - tbub)/(tdew - tbub)
            call hcvcps(1,tbub,vlb,xa,hbub,cv,cp,vsnd)
            call hcvcps(1,tdew,vvd,xa,hdew,cv,cp,vsnd)

47          continue
            icount = icount + 1
```

```
            hg1 = hbub + xqg*(hdew - hbub)
            call hpin(hg1,plotxv,xa,t2,xq,xl,xv,vl,vv,hl,hv)
            if(icount .lt. 200) then
                    if(abs(t2 - tsup) .lt. 0.1) then
                            hevp = hl + xq*(hv - hl)
                    else if(t2 .lt. tsup) then
                            xqg = xqg + 0.01
                            if(xqg .lt. 1.0) then
                                    go to 47
                            else
                                    write(lup,*)'2-PHASE TXV DID NOT CONVERGE'
                                    hevp = hdew
                                    sevp = entrop(tdew,vvd,xa)
                            end if
                    else
                            xqg = xqg - 0.006
                            if(xqg .gt. 0.0) then
                                    go to 47
                            else
                                    write(lup,*)'2-PHASE TXV DID NOT CONVERGE'
                                    hevp = hbub
                                    sevp = entrop(tbub,vlb,xa)
                            end if
                    end if
            else
                    write(lup,*)'MAX ITERATIONS EXCEEDED IN TXV'
                    hevp = hg1
            end if
            sgt = entrop(tsup,vv,xv)
            sft = entrop(tsup,vl,xl)
            sevp = sft + xq*(sgt - sft)
            vevp = vl + xq*(vv - vl)
      else
            call vit(tsup,plotxv,a,b,vlb,.true.,lv)
            call hcvcps(1,tsup,vlb,xa,hevp,cv.cp,vsnd)
            sevp = entrop(tsup,vlb,xa)
            vevp = vlb
      end if
      h3 = hevp/wm
      tcrit = tdew
      call critx(xa,tcrit,pcrit,vcrit)
      if(phi .gt. pcrit) then
            qtx = 0.0
            cop = 0.0
            sup = 0.0
            go to 9999
      end if
      call spin(sevp,phi,xa,t1s,xq,xl,xv,vl,vv,sl,sv)
      if(xq .ge. 1.0) then
            v1 = vv
      else if(xq .gt. 0.0) then
            v1 = vl + xq*(vv - vl)
      else
            v1 = vl
      end if
      call hcvcps(1,t1s,v1,xa,hcmps,cv,cp,vsnd)
      h1s = hcmps/wm
      h1 = h3 + (h1s - h3)/cn

      flow = vflow/vevp
      wtxv = flow*1000.0*(h1 - h3)

c     flow = wcomp/(1000.0*(h1 - h3))

      qtx = 1000.0*flow*(h3 - h2)
      qcond = 1000.0*flow*(h1 - h3)
      error = (qtx + wtxv - qcond)/qcond
      cop = qtx/wtxv
9999  continue
      return
      end
```

```
      subroutine vdot(ir1,tsup,vflow,wcomp,cn)

c     (C) Copyright Mainstream Engineering Corporation 1989

c     This subroutine determines the volumetric flow for
c     a positive displacement machine used in hpump1.

      real coeff(9,20), crit(5,20)
      character*6 href(20)
      logical lcrit,lv
      common/esdata/coeff,crit
      common/href1/href
      common/tol/tolr,itmax,lup
      real a(3,2), b(3,2)

      call bconst(ir1,ir1,0.0,0.0)
      wm = crit(1,ir1)

c                                              find enthalpy and entropy at
c                                              evaporator outlet.
      call bublt(275.0,xl,1.0,plo,vl,vevp,.false.,lcrit)
      call espar(0,tsup,1.0,a,b)
      call vit(tsup,plo,a,b,vevp,.false.,lv)
c                                              vevp = evaporator specific vol.

      call hcvcps(1,tsup,vevp,1.0,hevp,cv,cp,vsnd)
      h3 = hevp/wm
      sevp = entrop(tsup,vevp,1.0)
      s3 = sevp/wm

c                                              get condneser pressure

      call bublt(323.0,1.0,xv,phi,vcnd,vv,.true.,lcrit)

      call spin(sevp,phi,1.0,t1s,xq,xl,xv,vl,vv,sl,sv)

      if(xq .ge. 1.0) then
            v1 = vv
      else if(xq .gt. 0.0) then
            write(lup,*)'COMPRESSOR OUTLET QUALITY = ',XQ
            v1 = vl + xq*(vv - vl)
      else
            WRITE(LUP,*)'COMPRESSOR OUTLET SUBCOOLED'
            v1 = vl
      end if

c                                              now get isentropic compressor
c                                              outlet enthalpy

      call hcvcps(1,t1s,v1,1.0,hcmps,cv,cp,vsnd)
      h1s = hcmps/wm

c                                              adjust isentropic enthalpy to
c                                              true enthalpy using the comp-
c                                              ressor efficiency
      h1 = h3 + (h1s - h3)/cn

      flow = wcomp/(1000.0*(h1 - h3))
      vflow = flow*vevp

      return
      end
```

# APPENDIX D

# MODELING RESULTS - CONSTANT POWER COMPRESSOR OPERATION

## A. INTRODUCTION

This appendix contains the modeling results assuming constant power operation of the compressor. The modeling results presented earlier in this report assumed the compressor power was the power required to supply a constant volumetric flow rate. As was stated earlier in the report, constant power operation of the compressor could be achieved by supplying the compressor with power from a DC motor (rather than AC) or by varying the speed of the compressor to change its power requirement.

**TABLE D.1 - MODELING RESULTS FOR R-22/R-12 MIXTURE**

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 100.0 | 100.0 | High Pres (kPa) | 1933.3 | 1933.3 |
| | | Low Pres. (kPa) | 527.1 | 527.1 |
| | | Superheat (C) | 5.0 | 5.0 |
| | | Flow Rate (kg/s) | 0.2965 | 0.2965 |
| | | COPc | 4.0 | 4.0 |
| | | Q Evap (W) | 49823. | 49823. |
| | | % Capacity Change | --- | --- |
| 90.0 | 92.6 | High Pres (kPa) | 1924.1 | 1924.1 |
| | | Low Pres. (kPa) | 527.1 | 529.1 |
| | | Superheat (C) | 5.1 | 5.0 |
| | | Flow Rate (kg/s) | 0.3083 | 0.3083 |
| | | COPc | 4.0 | 4.0 |
| | | Q Evap (W) | 49584. | 49755. |
| | | % Capacity Change | - 0.48 | - 0.14 |
| 80.0 | 84.8 | High Pres (kPa) | 1903.8 | 1903.8 |
| | | Low Pres. (kPa) | 527.1 | 526.2 |
| | | Superheat (C) | 4.9 | 5.0 |
| | | Flow Rate (kg/s) | 0.3224 | 0.3219 |
| | | COPc | 4.0 | 4.0 |
| | | Q Evap (W) | 49712. | 49635. |
| | | % Capacity Change | - 0.22 | - 0.38 |
| 70.0 | 76.5 | High Pres (kPa) | 1872.4 | 1872.4 |
| | | Low Pres. (kPa) | 527.1 | 516.9 |
| | | Superheat (C) | 4.4 | 5.0 |
| | | Flow Rate (kg/s) | 0.3395 | 0.3330 |
| | | COPc | 4.0 | 3.9 |
| | | Q Evap (W) | 50240. | 49339. |
| | | % Capacity Change | + 0.84 | - 0.97 |
| 60.0 | 67.7 | High Pres (kPa) | 1829.4 | 1829.4 |
| | | Low Pres. (kPa) | 527.1 | 500.3 |
| | | Superheat (C) | 3.3 | 5.0 |
| | | Flow Rate (kg/s) | 0.3602 | 0.3420 |
| | | COPc | 4.1 | 3.9 |
| | | Q Evap (W) | 51238. | 48818. |
| | | % Capacity Change | + 2.84 | - 2.02 |
| 50.0 | 58.3 | High Pres (kPa) | 1773.6 | 1773.6 |
| | | Low Pres. (kPa) | 527.1 | 477.2 |
| | | Superheat (C) | 1.8 | 5.0 |
| | | Flow Rate (kg/s) | 0.3855 | 0.3491 |
| | | COPc | 4.2 | 3.9 |
| | | Q Evap (W) | 52823. | 48140. |
| | | % Capacity Change | + 6.02 | - 3.38 |

**TABLE D.1 - MODELING RESULTS FOR R-22/R-12 MIXTURE** (Concluded).

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 40.0 | 48.2 | High Pres (kPa) | 1703.2 | 1703.2 |
| | | Low Pres. (kPa) | 527.1 | 449.2 |
| | | Superheat (C) | - 0.1* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.3553 |
| | | COPc | ---- | 3.8 |
| | | Q Evap (W) | ---- | 47490. |
| | | % Capacity Change | ---- | - 4.68 |
| 30.0 | 37.5 | High Pres (kPa) | 1615.7 | 1615.7 |
| | | Low Pres. (kPa) | 527.1 | 418.7 |
| | | Superheat (C) | - 2.4* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.3626 |
| | | COPc | ---- | 3.8 |
| | | Q Evap (W) | ---- | 47111. |
| | | % Capacity Change | ---- | - 5.44 |
| 20.0 | 25.9 | High Pres (kPa) | 1507.6 | 1507.6 |
| | | Low Pres. (kPa) | 527.1 | 387.5 |
| | | Superheat (C) | - 5.0* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.3730 |
| | | COPc | ---- | 3.8 |
| | | Q Evap (W) | ---- | 47277. |
| | | % Capacity Change | ---- | - 5.11 |
| 10.0 | 13.4 | High Pres (kPa) | 1373.8 | 1373.8 |
| | | Low Pres. (kPa) | 527.1 | 356.8 |
| | | Superheat (C) | - 7.7* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.3899 |
| | | COPc | ---- | 3.9 |
| | | Q Evap (W) | ---- | 48351. |
| | | % Capacity Change | ---- | - 2.95 |
| 0.0 | 0.0 | High Pres (kPa) | 1207.9 | 1207.9 |
| | | Low Pres. (kPa) | 527.1 | 327.4 |
| | | Superheat (C) | - 10.6* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.4187 |
| | | COPc | ---- | 4.1 |
| | | Q Evap (W) | ---- | 50976. |
| | | % Capacity Change | ---- | + 2.31 |

* Compressor will fail due to slugging

TABLE D.2 - MODELING RESULTS FOR R-22/R-115 (R-502) MIXTURE

| MASS % R-22 | MASS% R-502 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 100.0 | 0.0 | High Pres (kPa) | 1933.3 | 1933.3 |
| | | Low Pres. (kPa) | 527.1 | 527.1 |
| | | Superheat (C) | 5.0 | 5.0 |
| | | Flow Rate (kg/s) | 0.2965 | 0.2965 |
| | | COPc | 4.0 | 4.0 |
| | | Q Evap (W) | 49823. | 49823. |
| 80.4 | 19.6 | High Pres (kPa) | 1904.1 | 1904.1 |
| | | Low Pres. (kPa) | 527.1 | 506.8 |
| | | Superheat (C) | 3.8 | 5.0 |
| | | Flow Rate (kg/s) | 0.3176 | 0.3058 |
| | | COPc | 4.1 | 4.0 |
| | | Q Evap (W) | 51425. | 49626. |
| | | % Capacity Change | + 3.22 | - 0.40 |
| 61.0 | 39.0 | High Pres (kPa) | 1902.3 | 1902.3 |
| | | Low Pres. (kPa) | 527.1 | 500.3 |
| | | Superheat (C) | 3.4 | 5.0 |
| | | Flow Rate (kg/s) | 0.3369 | 0.3204 |
| | | COPc | 4.2 | 4.0 |
| | | Q Evap (W) | 52057. | 49669. |
| | | % Capacity Change | + 4.48 | - 0.31 |
| 41.4 | 58.6 | High Pres (kPa) | 1946.5 | 1946.5 |
| | | Low Pres. (kPa) | 527.1 | 502.4 |
| | | Superheat (C) | 3.5 | 5.0 |
| | | Flow Rate (kg/s) | 0.3513 | 0.3356 |
| | | COPc | 4.1 | 3.9 |
| | | Q Evap (W) | 51204. | 49068. |
| | | % Capacity Change | + 2.77 | - 1.52 |
| 21.9 | 78.1 | High Pres (kPa) | 2056.5 | 2056.5 |
| | | Low Pres. (kPa) | 527.1 | 512.5 |
| | | Superheat (C) | 4.2 | 5.0 |
| | | Flow Rate (kg/s) | 0.3584 | 0.3491 |
| | | COPc | 3.9 | 3.8 |
| | | Q Evap (W) | 48566. | 47404. |
| | | % Capacity Change | - 2.52 | - 4.86 |
| 0.0 | 100.0 | High Pres (kPa) | 2282.0 | 2282.0 |
| | | Low Pres. (kPa) | 527.1 | 535.4 |
| | | Superheat (C) | 5.5 | 5.0 |
| | | Flow Rate (kg/s) | 0.3575 | 0.3625 |
| | | COPc | 3.5 | 3.5 |
| | | Q Evap (W) | 43657. | 44221. |
| | | % Capacity Change | - 12.4 | - 11.2 |

## TABLE D.3 - MODELING RESULTS FOR R-22/R-290 MIXTURE

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 100.0 | 100.0 | High Pres (kPa) | 1933.3 | 1933.3 |
| | | Low Pres. (kPa) | 527.1 | 527.1 |
| | | Superheat (C) | 5.0 | 5.0 |
| | | Flow Rate (kg/s) | 0.2965 | 0.2965 |
| | | COPc | 4.0 | 4.0 |
| | | Q Evap (W) | 49823. | 49823. |
| | | % Capacity Change | --- | --- |
| 90.0 | 82.1 | High Pres (kPa) | 2094.2 | 2094.2 |
| | | Low Pres. (kPa) | 527.1 | 583.5 |
| | | Superheat (C) | 8.2** | 5.0 |
| | | Flow Rate (kg/s) | 0.2561 | 0.2823 |
| | | COPc | 3.5 | 3.9 |
| | | Q Evap (W) | 44150. | 48351. |
| | | % Capacity Change | - 11.4 | - 2.95 |
| 80.0 | 67.1 | High Pres (kPa) | 2141.9 | 2141.9 |
| | | Low Pres. (kPa) | 527.1 | 621.0 |
| | | Superheat (C) | 10.3** | 5.0 |
| | | Flow Rate (kg/s) | 0.2334 | 0.2737 |
| | | COPc | 3.4 | 3.9 |
| | | Q Evap (W) | 42036. | 48706. |
| | | % Capacity Change | - 15.6 | - 2.24 |
| 70.0 | 52.3 | High Pres (kPa) | 2138.2 | 2138.2 |
| | | Low Pres. (kPa) | 527.1 | 631.6 |
| | | Superheat (C) | 10.9** | 5.0 |
| | | Flow Rate (kg/s) | 0.2181 | 0.2603 |
| | | COPc | 3.3 | 3.9 |
| | | Q Evap (W) | 41459. | 48824. |
| | | % Capacity Change | - 16.8 | - 2.01 |
| 60.0 | 43.3 | High Pres (kPa) | 2106.2 | 2106.2 |
| | | Low Pres. (kPa) | 527.1 | 620.7 |
| | | Superheat (C) | 10.4** | 5.0 |
| | | Flow Rate (kg/s) | 0.2069 | 0.2429 |
| | | COPc | 3.3 | 3.9 |
| | | Q Evap (W) | 41754. | 48426. |
| | | % Capacity Change | - 16.2 | - 2.80 |
| 50.0 | 33.8 | High Pres (kPa) | 2056.8 | 2056.8 |
| | | Low Pres. (kPa) | 527.1 | 600.0 |
| | | Superheat (C) | 9.3** | 5.0 |
| | | Flow Rate (kg/s) | 0.1984 | 0.2254 |
| | | COPc | 3.4 | 3.8 |
| | | Q Evap (W) | 42625. | 47951. |
| | | % Capacity Change | - 14.5 | - 3.76 |

TABLE D.3 - MODELING RESULTS FOR R-22/R-290 MIXTURE (Concluded).

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 40.0 | 25.4 | High Pres (kPa) | 1996.3 | 1996.3 |
| | | Low Pres. (kPa) | 527.1** | 576.9 |
| | | Superheat (C) | 8.0** | 5.0 |
| | | Flow Rate (kg/s) | 0.1919 | 0.2098 |
| | | COPc | 3.5 | 3.8 |
| | | Q Evap (W) | 43917. | 47700. |
| | | % Capacity Change | - 11.9 | - 4.26 |
| 30.0 | 17.9 | High Pres (kPa) | 1928.4 | 1928.4 |
| | | Low Pres. (kPa) | 527.1 | 554.9 |
| | | Superheat (C) | 6.7 | 5.0 |
| | | Flow Rate (kg/s) | 0.1870 | 0.1968 |
| | | COPc | 3.6 | 3.8 |
| | | Q Evap (W) | 45553. | 47765. |
| | | % Capacity Change | - 8.57 | - 4.13 |
| 20.0 | 11.3 | High Pres (kPa) | 1855.6 | 1855.6 |
| | | Low Pres. (kPa) | 527.1 | 534.9 |
| | | Superheat (C) | 5.5 | 5.0 |
| | | Flow Rate (kg/s) | 0.1834 | 0.1861 |
| | | COPc | 3.8 | 3.9 |
| | | Q Evap (W) | 47494. | 48150. |
| | | % Capacity Change | - 4.67 | - 3.36 |
| 10.0 | 5.4 | High Pres (kPa) | 1779.6 | 1779.6 |
| | | Low Pres. (kPa) | 527.1 | 517.1 |
| | | Superheat (C) | 4.4 | 5.0 |
| | | Flow Rate (kg/s) | 0.1810 | 0.1775 |
| | | COPc | 4.0 | 3.9 |
| | | Q Evap (W) | 49731. | 48836. |
| | | % Capacity Change | - 0.18 | - 1.98 |
| 0.0 | 0.0 | High Pres (kPa) | 1701.6 | 1701.6 |
| | | Low Pres. (kPa) | 527.1 | 501.4 |
| | | Superheat (C) | 3.3 | 5.0 |
| | | Flow Rate (kg/s) | 0.1797 | 0.1705 |
| | | COPc | 4.2 | 4.0 |
| | | Q Evap (W) | 52275. | 49804. |
| | | % Capacity Change | + 4.92 | - 0.04 |

** Potential freezing in water chiller

**TABLE D.4 - MODELING RESULTS FOR R-22/R-11 MIXTURE**

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 100.0 | 100.0 | High Pres (kPa) | 1933.3 | 1933.3 |
| | | Low Pres. (kPa) | 527.1 | 527.1 |
| | | Superheat (C) | 5.0 | 5.0 |
| | | Flow Rate (kg/s) | 0.2965 | 0.2965 |
| | | COPc | 4.0 | 4.0 |
| | | Q Evap (W) | 49823. | 49823. |
| | | % Capacity Change | --- | --- |
| 90.0 | 93.5 | High Pres (kPa) | 1812.2 | 1812.2 |
| | | Low Pres. (kPa) | 527.1 | 369.2 |
| | | Superheat (C) | - 5.8* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.2367 |
| | | COPc | ---- | 3.2 |
| | | Q Evap (W) | ---- | 39673. |
| | | % Capacity Change | ---- | - 20.4 |
| 80.0 | 86.4 | High Pres (kPa) | 1690.3 | 1690.3 |
| | | Low Pres. (kPa) | 527.1 | 243.8 |
| | | Superheat (C) | - 16.4* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.1959 |
| | | COPc | ---- | 2.6 |
| | | Q Evap (W) | ---- | 32692. |
| | | % Capacity Change | ---- | - 34.4 |
| 70.0 | 78.8 | High Pres (kPa) | 1565.5 | 1565.5 |
| | | Low Pres. (kPa) | 527.1 | 175.4 |
| | | Superheat (C) | - 25.5* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.1758 |
| | | COPc | ---- | 2.3 |
| | | Q Evap (W) | ---- | 29132. |
| | | % Capacity Change | ---- | - 41.5 |
| 60.0 | 70.4 | High Pres (kPa) | 1435.2 | 1435.2 |
| | | Low Pres. (kPa) | 527.1 | 133.5 |
| | | Superheat (C) | - 33.6* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.1665 |
| | | COPc | ---- | 2.2 |
| | | Q Evap (W) | ---- | 27385. |
| | | % Capacity Change | ---- | - 45.0 |
| 50.0 | 61.4 | High Pres (kPa) | 1295.8 | 1295.8 |
| | | Low Pres. (kPa) | 527.1 | 105.6 |
| | | Superheat (C) | - 40.9* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.1636 |
| | | COPc | ---- | 2.1 |
| | | Q Evap (W) | ---- | 26726. |
| | | % Capacity Change | ---- | - 46.4 |

**TABLE D.4 - MODELING RESULTS FOR R-22/R-11 MIXTURE** (concluded).

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 40.0 | 51.4 | High Pres (kPa) | 1142.6 | 1142.6 |
| | | Low Pres. (kPa) | 527.1* | 85.9 |
| | | Superheat (C) | - 47.8* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.1655 |
| | | COPc | ---- | 2.2 |
| | | Q Evap (W) | ---- | 26903. |
| | | % Capacity Change | ---- | - 46.0 |
| 30.0 | 40.5 | High Pres (kPa) | 969.4 | 969.4 |
| | | Low Pres. (kPa) | 527.1* | 71.2 |
| | | Superheat (C) | - 54.4* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.1724 |
| | | COPc | ---- | 2.2 |
| | | Q Evap (W) | ---- | 27948. |
| | | % Capacity Change | ---- | - 43.9 |
| 20.0 | 28.4 | High Pres (kPa) | 768.0 | 768.0 |
| | | Low Pres. (kPa) | 527.1* | 59.8 |
| | | Superheat (C) | - 60.8* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.1869 |
| | | COPc | ---- | 2.4 |
| | | Q Evap (W) | ---- | 30250. |
| | | % Capacity Change | ---- | - 39.3 |
| 10.0 | 15.0 | High Pres (kPa) | 527.6 | 527.6 |
| | | Low Pres. (kPa) | 527.1* | 50.8 |
| | | Superheat (C) | - 67.2* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.2178 |
| | | COPc | ---- | 2.8 |
| | | Q Evap (W) | ---- | 35304. |
| | | % Capacity Change | ---- | - 29.1 |
| 0.0 | 0.0 | High Pres (kPa) | 243.3 | 243.3 |
| | | Low Pres. (kPa) | 527.1* | 43.5 |
| | | Superheat (C) | - 73.6* | 5.0 |
| | | Flow Rate (kg/s) | ---- | 0.3303 |
| | | COPc | ---- | 4.3 |
| | | Q Evap (W) | ---- | 53722. |
| | | % Capacity Change | ---- | + 7.83 |

* Compressor will fail due to slugging

TABLE D.5 - MODELING RESULTS FOR R-22/R-13B1 MIXTURE

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 100.0 | 100.0 | High Pres (kPa) | 1933.3 | 1933.3 |
| | | Low Pres. (kPa) | 527.1 | 527.1 |
| | | Superheat (C) | 5.0 | 5.0 |
| | | Flow Rate (kg/s) | 0.2965 | 0.2965 |
| | | COPc | 4.0 | 4.0 |
| | | Q Evap (W) | 49823. | 49823. |
| | | % Capacity Change | --- | --- |
| 90.0 | 93.9 | High Pres (kPa) | 2018.4 | 2018.4 |
| | | Low Pres. (kPa) | 527.1 | 547.0 |
| | | Superheat (C) | 6.2 | 5.0 |
| | | Flow Rate (kg/s) | 0.2993 | 0.3101 |
| | | COPc | 3.8 | 3.9 |
| | | Q Evap (W) | 47113. | 48704. |
| | | % Capacity Change | - 5.44 | - 2.25 |
| 80.0 | 87.3 | High Pres (kPa) | 2104.0 | 2104.0 |
| | | Low Pres. (kPa) | 527.1** | 569.9 |
| | | Superheat (C) | 7.4** | 5.0 |
| | | Flow Rate (kg/s) | 0.3034 | 0.3267 |
| | | COPc | 3.6 | 3.8 |
| | | Q Evap (W) | 44599. | 47788. |
| | | % Capacity Change | - 10.5 | - 4.08 |
| 70.0 | 80.1 | High Pres (kPa) | 2190.0 | 2190.0 |
| | | Low Pres. (kPa) | 527.1** | 596.4 |
| | | Superheat (C) | 8.9** | 5.0 |
| | | Flow Rate (kg/s) | 0.3089 | 0.3470 |
| | | COPc | 3.4 | 3.8 |
| | | Q Evap (W) | 42252. | 47075. |
| | | % Capacity Change | - 15.2 | - 5.52 |
| 60.0 | 72.1 | High Pres (kPa) | 2276.4 | 2276.4 |
| | | Low Pres. (kPa) | 527.1** | 627.2 |
| | | Superheat (C) | 10.5** | 5.0 |
| | | Flow Rate (kg/s) | 0.3159 | 0.3718 |
| | | COPc | 3.2 | 3.7 |
| | | Q Evap (W) | 40044. | 46567. |
| | | % Capacity Change | - 19.6 | - 6.54 |
| 50.0 | 63.3 | High Pres (kPa) | 2363.3 | 2363.3 |
| | | Low Pres. (kPa) | 527.1** | 662.8 |
| | | Superheat (C) | 12.2** | 5.0 |
| | | Flow Rate (kg/s) | 0.3246 | 0.4021 |
| | | COPc | 3.0 | 3.7 |
| | | Q Evap (W) | 37970. | 46266. |
| | | % Capacity Change | - 23.8 | - 7.14 |

**TABLE D.5 - MODELING RESULTS FOR R-22/R-13B1 MIXTURE** (Concluded).

| MASS % R-22 | MOL % R-22 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 40.0 | 53.4 | High Pres (kPa) | 2450.3 | 2450.3 |
| | | Low Pres. (kPa) | 527.1** | 703.4 |
| | | Superheat (C) | 14.2** | 5.0 |
| | | Flow Rate (kg/s) | 0.3350 | 0.4392 |
| | | COPc | 2.9 | 3.7 |
| | | Q Evap (W) | 36016. | 46159. |
| | | % Capacity Change | - 27.7 | - 7.35 |
| 30.0 | 42.5 | High Pres (kPa) | 2536.7 | 2536.7 |
| | | Low Pres. (kPa) | 527.1** | 748.6 |
| | | Superheat (C) | 16.3** | 5.0 |
| | | Flow Rate (kg/s) | 0.3476 | 0.4839 |
| | | COPc | 2.7 | 3.7 |
| | | Q Evap (W) | 34183. | 46197. |
| | | % Capacity Change | - 31.4 | - 7.28 |
| 20.0 | 30.1 | High Pres (kPa) | 2621.2 | 2621.2 |
| | | Low Pres. (kPa) | 527.1** | 796.3 |
| | | Superheat (C) | 18.4** | 5.0 |
| | | Flow Rate (kg/s) | 0.3629 | 0.5369 |
| | | COPc | 2.6 | 3.7 |
| | | Q Evap (W) | 32483. | 46275. |
| | | % Capacity Change | - 34.8 | - 7.12 |
| 10.0 | 16.1 | High Pres (kPa) | 2700.8 | 2700.8 |
| | | Low Pres. (kPa) | 527.1** | 842.6 |
| | | Superheat (C) | 20.5** | 5.0 |
| | | Flow Rate (kg/s) | 0.3815 | 0.5976 |
| | | COPc | 2.5 | 3.7 |
| | | Q Evap (W) | 30943. | 46260. |
| | | % Capacity Change | - 37.9 | - 7.15 |
| 0.0 | 0.0 | High Pres (kPa) | 2769.9 | 2769.9 |
| | | Low Pres. (kPa) | 527.1** | 882.2 |
| | | Superheat (C) | 22.2** | 5.0 |
| | | Flow Rate (kg/s) | 0.4047 | 0.6647 |
| | | COPc | 2.4 | 3.7 |
| | | Q Evap (W) | 29615. | 46021. |
| | | % Capacity Change | - 40.6 | - 7.63 |

** Potential freezing in water chiller

## TABLE D.6 - MODELING RESULTS FOR R-11/R-12 MIXTURE

| MASS % R-11 | MOL % R-11 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 100.0 | 100.0 | High Pres (kPa) | 243.3 | 243.3 |
| | | Low Pres. (kPa) | 43.5 | 43.5 |
| | | Superheat (C) | 5.0 | 5.0 |
| | | Flow Rate (kg/s) | 2.6426 | 2.6426 |
| | | COPc | 4.3 | 4.3 |
| | | Q Evap (W) | 429779. | 429779. |
| | | % Capacity Change | --- | --- |
| 90.0 | 88.8 | High Pres (kPa) | 340.7 | 340.7 |
| | | Low Pres. (kPa) | 43.5** | 48.3 |
| | | Superheat (C) | 7.8 | 5.0 |
| | | Flow Rate (kg/s) | 2.0944 | 2.2254 |
| | | COPc | 3.3 | 3.5 |
| | | Q Evap (W) | 332596. | 353189. |
| | | % Capacity Change | - 22.6 | - 17.8 |
| 80.0 | 77.9 | High Pres (kPa) | 443.3 | 443.3 |
| | | Low Pres. (kPa) | 43.5** | 54.2 |
| | | Superheat (C) | 10.1 | 5.0 |
| | | Flow Rate (kg/s) | 1.8076 | 2.0316 |
| | | COPc | 2.8 | 3.1 |
| | | Q Evap (W) | 280220. | 314520. |
| | | % Capacity Change | - 34.8 | - 26.8 |
| 70.0 | 67.3 | High Pres (kPa) | 542.5 | 542.5 |
| | | Low Pres. (kPa) | 43.5** | 61.4 |
| | | Superheat (C) | 13.0 | 5.0 |
| | | Flow Rate (kg/s) | 1.6225 | 1.9326 |
| | | COPc | 2.5 | 2.9 |
| | | Q Evap (W) | 245480. | 291746. |
| | | % Capacity Change | - 42.9 | - 32.1 |
| 60.0 | 56.9 | High Pres (kPa) | 639.2 | 639.2 |
| | | Low Pres. (kPa) | 43.5** | 70.6 |
| | | Superheat (C) | 16.1 | 5.0 |
| | | Flow Rate (kg/s) | 1.4889 | 1.8899 |
| | | COPc | 2.2 | 2.8 |
| | | Q Evap (W) | 219778. | 278032. |
| | | % Capacity Change | - 48.9 | - 35.3 |
| 50.0 | 46.8 | High Pres (kPa) | 734.0 | 734.0 |
| | | Low Pres. (kPa) | 43.5** | 82.6 |
| | | Superheat (C) | 19.6 | 5.0 |
| | | Flow Rate (kg/s) | 1.3853 | 1.8906 |
| | | COPc | 2.0 | 2.7 |
| | | Q Evap (W) | 199450. | 270884. |
| | | % Capacity Change | - 53.6 | - 37.0 |

**TABLE D.6 - MODELING RESULTS FOR R-11/R-12 MIXTURE** (Concluded).

| MASS % R-11 | MOL % R-11 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 40.0 | 37.0 | High Pres (kPa) | 827.6 | 827.6 |
| | | Low Pres. (kPa) | 43.5** | 98.9 |
| | | Superheat (C) | 23.6** | 5.0 |
| | | Flow Rate (kg/s) | 1.3011 | 1.9350 |
| | | COPc | 1.8 | 2.7 |
| | | Q Evap (W) | 182639. | 269778. |
| | | % Capacity Change | - 57.5 | - 37.2 |
| 30.0 | 27.4 | High Pres (kPa) | 920.9 | 920.9 |
| | | Low Pres. (kPa) | 43.5** | 122.2 |
| | | Superheat (C) | 28.3** | 5.0 |
| | | Flow Rate (kg/s) | 1.2301 | 2.0353 |
| | | COPc | 1.7 | 2.8 |
| | | Q Evap (W) | 168290. | 275770. |
| | | % Capacity Change | - 60.8 | - 35.8 |
| 20.0 | 18.0 | High Pres (kPa) | 1014.7 | 1014.7 |
| | | Low Pres. (kPa) | 43.5** | 157.9 |
| | | Superheat (C) | 34.0** | 5.0 |
| | | Flow Rate (kg/s) | 1.1687 | 2.2247 |
| | | COPc | 1.6 | 2.9 |
| | | Q Evap (W) | 155748. | 292340. |
| | | % Capacity Change | - 63.8 | - 32.0 |
| 10.0 | 8.9 | High Pres (kPa) | 1109.9 | 1109.9 |
| | | Low Pres. (kPa) | 43.5** | 217.9 |
| | | Superheat (C) | 41.9** | 5.0 |
| | | Flow Rate (kg/s) | 1.1143 | 2.5875 |
| | | COPc | 1.4 | 3.3 |
| | | Q Evap (W) | 144570. | 328535. |
| | | % Capacity Change | - 66.4 | - 23.6 |
| 0.0 | 0.0 | High Pres (kPa) | 1207.9 | 1207.9 |
| | | Low Pres. (kPa) | 43.5** | 327.4 |
| | | Superheat (C) | 54.8** | 5.0 |
| | | Flow Rate (kg/s) | 1.0653 | 3.3493 |
| | | COPc | 1.3 | 4.1 |
| | | Q Evap (W) | 134471. | 407804. |
| | | % Capacity Change | - 68.7 | - 5.11 |

** Potential freezing in water chiller

**TABLE D.7 - MODELING RESULTS FOR R-11/R-22 MIXTURE**

| MASS % R-11 | MOL % R-11 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 100.0 | 100.0 | High Pres (kPa) | 234.3 | 234.3 |
| | | Low Pres. (kPa) | 43.5 | 43.5 |
| | | Superheat (C) | 5.0 | 5.0 |
| | | Flow Rate (kg/s) | 2.6426 | 2.6426 |
| | | COPc | 4.3 | 4.3 |
| | | Q Evap (W) | 429779. | 429779. |
| | | % Capacity Change | --- | --- |
| 90.0 | 85.0 | High Pres (kPa) | 527.6 | 527.6 |
| | | Low Pres. (kPa) | 43.5 | 50.8 |
| | | Superheat (C) | 8.6** | 5.0 |
| | | Flow Rate (kg/s) | 1.6134 | 1.7426 |
| | | COPc | 2.6 | 2.8 |
| | | Q Evap (W) | 261724. | 282428. |
| | | % Capacity Change | - 39.1 | - 34.3 |
| 80.0 | 71.6 | High Pres (kPa) | 768.0 | 768.0 |
| | | Low Pres. (kPa) | 43.5 | 59.8 |
| | | Superheat (C) | 12.4** | 5.0 |
| | | Flow Rate (kg/s) | 1.2937 | 1.4948 |
| | | COPc | 2.1 | 2.4 |
| | | Q Evap (W) | 209837. | 242002. |
| | | % Capacity Change | - 51.2 | - 43.7 |
| 70.0 | 59.5 | High Pres (kPa) | 969.4 | 969.4 |
| | | Low Pres. (kPa) | 43.5 | 71.2 |
| | | Superheat (C) | 16.2** | 5.0 |
| | | Flow Rate (kg/s) | 1.1126 | 1.3796 |
| | | COPc | 1.8 | 2.2 |
| | | Q Evap (W) | 180873. | 223581. |
| | | % Capacity Change | - 57.9 | - 48.0 |
| 60.0 | 48.6 | High Pres (kPa) | 1142.6 | 1142.6 |
| | | Low Pres. (kPa) | 43.5 | 85.9 |
| | | Superheat (C) | 20.2** | 5.0 |
| | | Flow Rate (kg/s) | 0.9877 | 1.3239 |
| | | COPc | 1.6 | 2.2 |
| | | Q Evap (W) | 161313. | 215226. |
| | | % Capacity Change | - 62.5 | - 49.9 |
| 50.0 | 38.6 | High Pres (kPa) | 1295.8 | 1295.8 |
| | | Low Pres. (kPa) | 43.5 | 105.6 |
| | | Superheat (C) | 24.6** | 5.0 |
| | | Flow Rate (kg/s) | 0.8929 | 1.3087 |
| | | COPc | 1.5 | 2.1 |
| | | Q Evap (W) | 146830. | 213808. |
| | | % Capacity Change | - 65.8 | - 50.3 |

**TABLE D.7 - MODELING RESULTS FOR R-11/R-22 MIXTURE** (Concluded).

| MASS % R-11 | MOL % R-11 | PARAMETER | TXV | NO TXV |
|---|---|---|---|---|
| 40.0 | 29.6 | High Pres (kPa) | 1435.2 | 1435.2 |
| | | Low Pres. (kPa) | 43.5** | 133.5 |
| | | Superheat (C) | 29.4** | 5.0 |
| | | Flow Rate (kg/s) | 0.8166 | 1.3323 |
| | | COPc | 1.4 | 2.2 |
| | | Q Evap (W) | 135510. | 219802. |
| | | % Capacity Change | - 68.5 | - 48.9 |
| 30.0 | 21.2 | High Pres (kPa) | 1565.5 | 1565.5 |
| | | Low Pres. (kPa) | 43.5** | 175.4 |
| | | Superheat (C) | 34.9** | 5.0 |
| | | Flow Rate (kg/s) | 0.7530 | 1.4068 |
| | | COPc | 1.3 | 2.3 |
| | | Q Evap (W) | 126375. | 233055. |
| | | % Capacity Change | - 70.6 | - 45.8 |
| 20.0 | 13.6 | High Pres (kPa) | 1690.3 | 1690.3 |
| | | Low Pres. (kPa) | 43.5** | 243.8 |
| | | Superheat (C) | 41.7** | 5.0 |
| | | Flow Rate (kg/s) | 0.6986 | 1.5674 |
| | | COPc | 1.2 | 2.6 |
| | | Q Evap (W) | 118835. | 261537. |
| | | % Capacity Change | - 72.3 | - 39.2 |
| 10.0 | 6.5 | High Pres (kPa) | 1812.2 | 1812.2 |
| | | Low Pres. (kPa) | 43.5** | 362.9 |
| | | Superheat (C) | 51.1** | 5.0 |
| | | Flow Rate (kg/s) | 0.6512 | 1.8934 |
| | | COPc | 1.1 | 3.2 |
| | | Q Evap (W) | 112521. | 317381. |
| | | % Capacity Change | - 73.8 | - 26.2 |
| 0.0 | 0.0 | High Pres (kPa) | 1933.3 | 1933.3 |
| | | Low Pres. (kPa) | 43.5** | 527.1 |
| | | Superheat (C) | 64.4** | 5.0 |
| | | Flow Rate (kg/s) | 0.6093 | 2.3724 |
| | | COPc | 1.1 | 4.0 |
| | | Q Evap (W) | 107185. | 398580. |
| | | % Capacity Change | - 75.1 | - 7.26 |

** Potential freezing in water chiller